



REPORT  
ON  
EPIDEMIC CEREBRO-SPINAL MENINGITIS  
IN INDIA.

BY  
CAPTAIN C. J. ROBERTSON-MILNE, M B., I.M.S.  
*On special duty.*

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# REPORT

ON

## EPIDEMIC CEREBRO-SPINAL MENINGITIS IN INDIA.

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### CEREBRO-SPINAL FEVER IN INDIA.

#### I.—Historical.

THE disease known as Epidemic Cerebro-Spinal Meningitis, or better still as Cerebro-Spinal Fever, has prevailed in India for almost quarter of a century, but this fact has not been appreciated. German, French, and American writers are silent on the subject, while the only reference to its occurrence in India, which I have been able to find in British Journals, is that by Dr. Bruce Low, (4) who, in a paper read before the Epidemiological Society in 1898, briefly referred to the epidemics of the disease reported by Major W. J. Buchanan from Bhagalpur. The chief reason, perhaps, why authorities should have thus neglected to include India among the countries in which the disease has been observed, is that most of the records of its occurrence are either contained within voluminous official reports or remain concealed in the archives of hospitals, regiments, or prisons. The disease is one which has attracted much attention only within the past decade; but nearly a hundred years have passed since Danielson and Mann in Massachusetts and Vieusseux in Geneva independently recognised it as a distinct disorder. Inaccurate to a certain degree as their observations were, yet they served, as Dr. Cecil Wall (27) has pointed out, to call attention to the existence of a meningeal disease of a malignant and infective type: historical and other data with regard to epidemic cerebro-spinal meningitis are accordingly reckoned from the year 1806, in which their observations were made. In the United States and on the Continent of Europe the disease has, from time to time prevailed widely. An extensive literature, therefore, exists

The most complete of recent monographs are those by Councilman, Malloy and Wright, (1) by Netter, (2) and by Jaeger (3). The first-named, in recording the epidemic at Boston in 1898, give an historical account of the incidence of the disease, particularly in the United States, but also in other countries more especially in France and Germany, whose inhabitants would appear to have suffered to a greater degree than those of other countries in Europe. Netter, who is the chief authority in France, has traversed practically the same ground in his articles in the *Twentieth Century Practice of Medicine*. The most elaborate historical record, however, is that by Jaeger and is contained in his handbook to the disease. The disorder has occurred less frequently in the United Kingdom, an exhaustive account of its incidence in these isles is contained in the paper by Dr Bruce Low, to which reference has already been made.

The perusal of these and other historical surveys has indicated many important features of this remarkable disease. Prominent among these is its curious geographical distribution, for which no reason can as yet be assigned. Why, for instance, should the inhabitants of the United States have suffered more frequently and more severely than those of Canada? Climate cannot be urged in explanation of this, for the disease is one which affects temperate climes. Similarly, fewer outbreaks have been recorded from Spain than from France, from Italy than from Germany. In Ireland the disease has been more often met with than in England. Another feature is that, although large tracts of country may be said to be affected, yet in these it will be found that outbreaks have only occurred in certain towns or villages, generally widely apart from and not particularly connected, commercially or otherwise, with each other. How very different are the ravages of plague, which, when epidemic, passes from village to village and thence to town and city, sparing none. Probing the matter still deeper, one finds that the incidence of cerebro-spinal fever is not really great and that in a given community comparatively few persons suffer, it is on rare occasions that more than one member of a household is attacked, rarer still that plural attacks in a family should occur synchronously. Here, again, the contrast to plague will be remarked. In one point, however, other infective disorders are simulated by cerebro-spinal fever, the disease does not prevail continuously; for periods of many years outbreaks are unknown throughout the world. It is believed, however, that these intervals are bridged over by sporadic attacks, whose nature is considered by many to be identical with that of the epidemic form.

It will be evident, then, that although the disease may exist in two or more countries simultaneously, yet no connection is traceable between these outbreaks, for the disease apparently does not follow the ordinary lines of traffic and commerce. Such being the case, no purpose would be served by reiterating the history of the disease in Europe, North America, or elsewhere. This has been already sufficiently well done in the monographs mentioned above. With regard to Asia, I have found a solitary record of the occurrence of the disease outside India. Dr. Bruce Low (4) states that about 1874-1875 the disease was epidemic in Persia. This period is an interesting one, for the disease was then more prevalent than it had been, and in addition to Persia it was reported from other places for the first time. Among these was Fiji, into which the disease was introduced in 1876 (6). About the same time it seems to have appeared in India, prior to this date no trace of its occurrence is to be found in the numerous writings and researches of Indian medical officers which I have been able to consult. Neither Twining (7) nor Moirhead (8) mention it at all. Maclean (9) and Fayrer (10) are similarly silent on this subject. Chevers (11) states that some three cases resembling the description of the disease came under his observation, and he adds that Ewart, Goodeve, and Duka never saw a case, although the two latter "watched sedulously for the disease. Macpherson, he adds, treated a suspicious case in an East Indian girl in Calcutta.

It would seem that Vandyke Carter (12) was the first to meet with cerebro-spinal fever in India. In Appendix B of his book on spirillum fever under "Concurrent Fevers at Bombay," he describes the clinical and pathological appearances of what seems to have been an instance of the disease. He also notes that he had seen three other attacks in boys aged about fifteen, presenting typical symptoms including herpetic and petechial eruptions, all of whom recovered. Several of his cases of remittent fever at the same time exhibited unusual meningeal symptoms, and in the autopsy of one of these the pathological appearances resembled those of cerebro-spinal fever; in two other cases admitted moribund a similar state of affairs was revealed after death. He writes finally, "All these instances probably belong to one series since suppurative meningitis is not known to occur in ordinary malarial fevers." Although Carter did not recognise the malady, it seems possible from the above that a small epidemic of cerebro-spinal fever occurred in Bombay in 1878. In 1886 at a meeting of the Bombay Medical and Physical Society to discuss a communication on the prevalence of cerebro-spinal fever in the Nara (Sind) Jail, (13)

Carter related a sporadic case which he had met with in the previous year and which, he said, corresponded exactly to those seen by him in 1878

To Surgeon (now Lieutenant-Colonel) H. P. Dimmock, (14) however, belongs the honour of recognising and fully describing the disease in its epidemic form. In April 1884 he submitted an elaborate and very interesting report of an epidemic which prevailed among the convicts of the Shikarpur Jail during the cold season of 1883-84. The mortality in this jail had, for some years previously, attracted attention. sporadic cases of fever with sudden cerebral symptoms, frequently fatal, had raised the death-rate, these had been returned as "Congestive Apoplexy," "Inflammation of the Brain," etc. It was not until Dimmock took over charge of the jail that he reconciled the true nature of the disease with that known as cerebro-spinal fever or meningitis. The story of this outbreak is best told in Dimmock's own words:—"In May 1883 two hundred of the finest men were marched into Sukkur and were there employed on the embankment approaches and other works of the Indus River Bridge. They were encamped in 'lowties' (huts) on an open level ground among the low-lying magnesian limestone hills. Towards the end of October, the weather, which had been very hot, changed and a cool east wind began to blow at night and in the early morning, at the same time it began to be very cold and coincidently with this there appeared amongst the convicts of the Sukkur gang first of all and then amongst convicts of the jail at Shikarpur cases of the disease which is known as cerebro-spinal fever." In this epidemic there were thirty-eight attacks with twenty-seven deaths; but, as a reference to the statistics of the Sanitary Commissioner with the Government of India would seem to show, only a few of these would appear to have been thus officially returned. Similar cases occurred at the same time among the Shikarpur Police and also among the free populations of the Shikarpur, Hyderabad, and Jacobabad districts. In Hyderabad a small epidemic of thirteen attacks with nine deaths was observed in 1884-85 at the penal settlement of Nara by the officer in charge, Assistant Surgeon Dadachanji.

Although the above is the earliest accurate record which we possess in India, the disease had been previously notified from certain jails and native regiments. In 1881 cerebro-spinal fever appeared for the first time in the statistical tables which accompany the annual report of the Sanitary Commissioner with the Government of India (15); in every subsequent year attacks and deaths have been recorded in that compilation, as a reference to the following table will show

Table I.

*Statistics of the incidence and mortality from Cerebro-Spinal Fever and from other forms of Meningitis in the Native Army and in the Jails of India during the years 1881—1901 (inclusive).*

NATIVE ARMY.						JAILS				
Year	Annual Strength	Cerebro Spinal Meningitis or Fever.		All other forms of Meningitis		Annual strength	Cerebro Spinal Meningitis or Fever		All other forms of Meningitis	
		Admis- sions	Deaths	Admis- sions	Deaths		Admis sions	Deaths	Admis- sions	Deaths
1881	133,453	2	—	11	10	100,856	1	—	15	22
1882	126,589	—	—	11	9	91,059	2	2	23	20
1883	126,525	1	1	13	13	88,187	7	5	29	29
1884	127,477	1	1	10	9	85,500	18	12	14	14
1885	123,628	12	8	7	3	82,644	11	13	27	25
1886	130,241	3	2	7	3	84,909	28	20	18	15
1887	140,086	—	—	12	8	79,471	25	17	20	15
1888	145,252	—	—	12	11	91,445	38	28	16	13
1889	145,540	—	—	17	15	96,121	48	31	24	23
1890	144,738	—	—	8	7	96,610	23	22	28	23
1891	143,970	2	2	14	7	101,019	35	29	14	12
1892	145,340	—	—	17	11	103,159	17	15	23	21
1893	143,457	—	—	6	7	101,737	15	10	15	12
1894	143,948	1	1	7	3	101,965	4	4	19	12
1895	144,693	—	—	17	12	106,337	8	5	8	7
1896	145,692	—	—	13	10	110,090	7	7	25	18
1897	145,259	—	—	10	7	118,107	13	10	22	20
1898	143,858	1	1	10	7	111,344	24	15	12	9
1899	146,761	12	11	13	13	110,016	29	24	14	12
1900	155,452	3	2	7	6	121,811	99	79	15	15
1901	153,547	28	21	16	13	117,203	141	102	28	21
TOTAL	140,738	66	50	238	184	100,123	593	450	409	361

In the above table I have, for purposes of comparison, tabulated all the attacks and deaths from other forms of meningitis, excepting the Tubercular variety, which is essentially a disease of children and which



all authorities are agreed in considering a rare affection among adults (16) Under meningitis I have, therefore, classed together all the figures under the following headings which have appeared in various years :—"Spinal Meningitis," "Cerebral Meningitis," "Inflammation of the Membranes, Brain and Cord," "Inflammation of the Brain and Membranes," "Inflammation of the Cerebral Membranes," "Inflammation of the Cord and Membranes," "Leptomeningitis "

Among British troops in India, during the same period, there have been five attacks and one death attributed to cerebro-spinal fever, there have also been a number of cases returned as "meningitis" under one or other of the above headings For the free civil population of India there are no figures available

It will thus be seen that during the 21 years 1881—1901 there have been recorded from the Native Army with an average annual strength of 140,738, sixty-six attacks and fifty deaths from cerebro-spinal fever and from other forms of meningitis two hundred and thirty-eight attacks with one hundred and eighty-four deaths. From cerebro-spinal fever in jails, with an average annual population of 100,123, five hundred and ninety-three attacks with four hundred and fifty deaths have been recorded and from other forms of meningitis four hundred and nine attacks with three hundred and sixty-one deaths. It ought to be remarked here that these figures relate mainly to persons between the ages of sixteen and sixty They do not refer to young children in whom, it is stated by some authorities, 50 per cent of the attacks occur. There are in the native army some six hundred boys between the ages of ten and sixteen, who are employed as buglers, etc, and about an equal number of juvenile offenders of the same age in penitentiaries. In the records which I have obtained I have found no instance of either cerebro-spinal fever or of meningitis in such youths

A problem with which we are confronted by these statistics is what was the nature of these other forms of meningitis. This is a difficult matter to determine, for it was not possible to obtain the records of all the cases thus diagnosed. However, in the absence of bacteriological data, the perusal of these would have proved of no great value. Of simple meningitis as a primary disease comparatively little is known even at the present day. It is rarely met with among adults, but in children it is frequently observed in two forms, the Tubercular and that known as posterior basic meningitis. In adults meningitis is commonly remarked as a sequel to other infectious disorders, such as measles, small-pox, etc, but especially to pneumonia. It is possible that a large number of these cases of meningitis in the Indian army and jails were

secondary to pneumonic pulmonary affections. In Appendix B will be found the records of two such cases, one diagnosed by Lamb from the Yenowda Prison at Poona, the other by Dinu at the Medical College at Calcutta. During the period of my deputation I endeavoured to obtain material from and records of cases of meningitis other than cerebro-spinal fever, but in this, as the sequel shows, I was singularly unsuccessful. Apparently during 1903-1904 meningitis occurred as rarely as did cerebro-spinal fever. The cases thus brought to my notice were these. In April 1903 a case of acute diffuse meningitis was reported by the Superintendent of the Allahabad Central Prison, who, in reporting the matter officially, stated that three similar cases had thus been previously returned. The records of these attacks, which are tabulated in Table II, were forwarded to me by the Inspector-General of Prisons. The excellent clinical and pathological notes of these cases would seem to show that the first three were sporadic instances of cerebro-spinal fever, while in the fourth the meningitis was secondary to acute lobar pneumonia.

Table II.

*Cases of Meningitis in the Allahabad Central Prison from 1901 to 1903*

No	Date of death	Cause
I	2nd June 1901	Leptomeningitis, purulent.
II.	5th November 1901	Meningitis, diffuse, acute
III	10th January 1902	Meningitis, diffuse, acute
IV	21st April 1903	Meningitis, diffuse, acute

In June 1904 Captain Oxley, I.M.S., reported a case of meningitis from the civil hospital at Seone. The man had been found on the road in a dying state and brought to hospital, where he succumbed shortly after admission. An autopsy revealed a purulent meningitis and Captain Oxley sent me portions of the brain and cord preserved in methylated spirit. Sections of these tissues stained by Nissl's method revealed the presence of an extensive inflammation of the pia arachnoid with a leucocytic exudation which penetrated deeply into the substance of brain and cord. The cells of the exudate were polymorphonuclear in type but were much shrunken, diplococci could not be made out in them. By Marchi's method a diffuse degeneration was indicated. It was unfortunate that these tissues had not been originally placed in a more suitable preservative. With the establishment of research laboratories in India, it is to be hoped that medical officers will be induced to send material from all such cases, sufficient for a complete bacteriological diagnosis. Extremely interesting data would be forthcoming from a

large series, and the obscurity which exists with regard to these cases of meningitis would be to a great extent removed.

As the available records would then appear to indicate, the history of cerebro-spinal fever resolves itself almost entirely into a record of its incidence in jails, of which institutions the inmates have suffered more than any other section of the community. In every year since 1881 cases have been reported by medical officers of jails, chiefly from Northern India. The jails of Madras and Burma, excepting Coimbatore and Akyab, have been free from outbreaks. From the jail at Akyab five cases of purulent meningitis were reported by the Superintendent to have occurred during 1903, and these have been described by him (28). In two of his cases he stated that he had found "pneumococci" in the exudate, but whether he stained these by Gram's method or recovered them by culture is not apparent from the context. In the previous year three similar cases had been recorded from the same jail.

From the Bombay Presidency proper one severe outbreak in a prison has been chronicled. This was at the Central Prison at Ahmedabad in 1902, a famine year. Thirty-eight attacks with thirty-two deaths were notified. Many of them were bacteriologically diagnosed by Lamb at Bombay, who found the meningococcus in every case he examined (26). At the same time the surrounding famine-stricken districts were affected by the same disease, and Major Oll (25) recorded a number of cases in children in the camps of the relief works. The Yerrowda Prison at Poona is the only other such institution in the Western Presidency from which cases of cerebro-spinal fever have been recorded. Five of these were thus returned in 1901. One of the two fatal instances was investigated by Lamb, who concluded that it was of the pneumococcal variety and secondary to a lung affection. From the Central Provinces sporadic attacks have been reported by the medical officers of several of the jails but, as in Bombay, only one such institution, the Central Prison at Raipur, was the scene of an epidemic. Between November 1899 and April 1900 twenty-two consecutive fatal attacks were recorded by the then Superintendent, Major Henvey, (21) whose detailed account of them, is contained in the *Indian Medical Gazette* of the latter year.

In most of the Bengal jails instances of cerebro-spinal fever have been observed at various times. Moorhead states that up to 1894 one-fifth of them had been affected. Minor outbreaks occurred at the District Jail at Burdwan in 1885 and at the Central Jail at Hazaribagh in 1889. The latter is described by Moorhead in his paper on the disease read before the Indian Medical Congress of 1894 (17). There were, during the year 1899, fourteen attacks with eleven deaths. Of

the other central jails those at Buxai, Midnapur, and Dacca have escaped affection, while from the similar institutions at Alipur and Bhagalpur remarkable proof has been afforded of the tenacity with which the infectious agent of cerebro-spinal fever attaches itself to a group of buildings. In 1886, for the first time, eighteen attacks with eleven deaths were recorded by the medical officer of the prison at Alipur: the patients came from all parts of the jail and had mostly been in good health prior to attack. A committee consisting of Drs. Cleghorn, Joubert, and Clarke investigated these cases, they considered them to be instances of cerebro-spinal fever and brought forward evidence to show that similar attacks had been observed about the same time among the civil population of Calcutta, and that cases had also been reported from emigrant ships on the Hooghly and from various districts of the United Provinces and Bengal. In 1887, in the same prison, ten fatal attacks occurred and from that year until the end of 1891 sporadic cases were recorded at intervals. Then mortality was very high and a special standing committee was appointed to investigate each case. Since 1891 the jail has been practically free from the disease. Its place, however, as an infected centre has been taken by the jail at Bhagalpur, from which one hundred attacks, seventy of which were fatal, were notified from January 1, 1897, up to the end of June 1904. Buchanan, (18) Stevens, (19) and Newman, (20) who were successively in charge of this jail, have submitted elaborate records of the eighty nine cases which occurred up to the end of 1902. These were comprised in five consecutive outbreaks, as is shown in Table III. Since 1902 the cases have been sporadic and have generally occurred at long intervals. Drury and Rogers have at different times verified the bacteriological nature of these attacks as being identical with those observed in Europe and North America. From Assam no outbreak has been announced and very few attacks have occurred among the prisoners in that province.

Table III.

*The epidemics of Cerebro-Spinal Fever at the Bhagalpur Jail*

Serial number	Date of first case		Date of 1st case		No of cases	No of deaths
I	11th January	1897	18th April	1897	9	8
II	17th October	1897	20th April	1898	14	7
III	22nd August	1890	31st July	1900	24	17
IV	7th October	1900	31st July	1901	20	16
V	4th September	1901	19th March	1902	22	14
					89	62

The jails in the United Provinces were not seriously affected until 1899. In that year, an outbreak occurred in the district jail at Muzapur, while in the following year small epidemics were reported from the jails at Fatehpur and Allahabad. In 1901 the Superintendent of the district jail at the latter place reported a further series of attacks and deaths from this disorder, twenty five prisoners, of whom twenty-one succumbed, were attacked. In the Sultanpur Jail in the same year there were eight consecutive fatal cases.

In the Punjab the most prominent outbreaks have taken place at the jails of Chenawan, Mung Rasul, and Lahore, but in nearly every jail in this province cases have been observed notably at Rawalpindi, Ferozepore, and Rohtak. The epidemic at Chenawan occurred in 1886. The prisoners were then employed on canal works, and it is a curious and noteworthy fact that two other of the most important Indian epidemics have been recorded from among prisoners similarly employed. These were the Shikarpur outbreak chronicled by Dimmock and the outbreak at Mung Rasul in 1901. This latter is further remarkable in that the jail was a new one and had only been recently occupied. The prisoners suffered severely. forty-nine attacks were noted in 1901 and twenty-four in 1902. The mortality was nearly 68 per cent. At the same time as the second outbreak pneumonia was very fatally prevalent and eventually the jail continued to be so unhealthy from these causes that it was found necessary to temporarily close it, all other measures having proved of no avail.

The European army has so far escaped a serious prevalence of the disease, but from the native army, especially from regiments stationed on the North-West Frontier, medical officers have occasionally reported small outbreaks of the disease. In November 1885 the disease broke out among the sepoys of the 2nd Punjab Infantry at Kohat, twelve attacks, ten of which ended fatally, were notified up to February 1886. In another regiment at the same station a fatal case occurred during the same period. In 1901, when the disease prevailed widely and to a greater degree than previously, outbreaks were recorded by the medical officers of the 8th Bombay Infantry at Dellu and the 47th Sikhs at Sialkot from their respective regiments. There were also four admissions from this disorder among the troops forming the Chitral Garrison. Captain Kelly, the Medical Officer in charge of this, informed me that the disease prevailed at the same time throughout the lower Chitral valley, having been imported thence from Asmar, and that he had heard of cases occurring to the west of Chitral in Kafirstan.

No outbreak of any magnitude has been chronicled as having taken place among the general community. The disease has, however, prevailed

widely, but in a thickly populated country like India, liable as it is for various reasons to intense and severe epidemics of disorders such as plague, cholera, small-pox, etc., a disease with a comparatively slight incidence as cerebro spinal fever would certainly be overlooked and neglected by the apathetic populace. This is borne out by the following example of such an outbreak in a remote village. In February 1904 Lieutenant H. R. Nutt, I.M.S., attached to the 22nd Punjab, sent me the notes and some purulent material obtained by puncture from the knee-joint and spinal canal of a patient in his regimental hospital at Dehra Ghazi Khan. I isolated the meningococcus from the material. The case is interesting; for, on enquiring from the Civil Surgeon of that station, Major D. T. Lane, I.M.S., about the prevalence of the disease in his district, he wrote and told me that during the previous cold weather it had been prevalent in the hills around the station. It was known locally as "Sarsam." The disease had again broken out in the neighbourhood in January 1904, when, at a distant village, "Jhok Utra," twenty-three persons had been attacked, of whom twenty had died. Two women, who were first cousins, living in the next village "Basti Yaki," went to a funeral of one of the cases at Jhok Utra. Both contracted the disease and both died. All this occurred within the month, and when the Civil Surgeon heard of it, the outbreak was practically at an end. The people had not reported the matter earlier, as they regarded it as "nothing out of the common." At Miraj in the Bombay Presidency outbreaks among children have been recorded by Dr. J. Rutter Williamson, who bacteriologically diagnosed many of his cases. The prevalence of the disease in the Ahmedabad district in 1902 has been already alluded to. Although no other record of an outbreak is extant, yet sporadic instances of the disease have been constantly met with during the past quinquennium in most of the districts, and especially in the larger towns of Northern India.

Up to 1901-1902, the disease had prevailed in a comparatively slight fashion, but it then began to so seriously affect the inmates of certain jails and the soldiers of certain regiments that an investigation into the disease was ordered, and in August 1902 I was deputed to carry this out. As subsequent events proved, however, the disease had by that time begun to abate, and during the period of my deputation up to August 1904 no epidemics occurred such as had been previously recorded. A few sporadic cases were notified to me from places widely distant from each other. It was not possible for me to see all of these, but whenever I could I visited the jails from which they had been reported. I thus saw cases in the jails at Fyzabad and Bhagalpur. As the Superintendent

of the latter jail continued to report cases, I revisited the jail in April 1904 with a view to study more accurately the conditions of life therein and to be present, if possible, when an attack occurred. I had spent about five days there when my stay was abruptly terminated by a telegram, which stated that four prisoners had been attacked by the disease at the Central Jail at Lahore. I proceeded to Lahore at once and, on arriving there, ascertained the following history of the outbreak. The jail had been until 1904 particularly healthy. In 1902 forty-seven deaths were recorded, a mortality of 32·7 per mille. 1903 was a still healthier year, for with a large population there were only twenty-seven deaths, the mortality-rate falling to 17·9. Dysentery, pulmonary tuberculosis, and pneumonia were the diseases which contributed most largely to the death-rate. In 1904 January was a fairly healthy month, but in February pneumonia of a remarkably fatal type prevailed, and eighteen prisoners were admitted suffering from this complaint, ten of whom succumbed. In the following two months this outbreak gradually subsided, but up to the end of April pneumonia had accounted for thirty attacks and twelve deaths in the jail. Neither plague nor influenza were then specially prevalent. No particular barrack nor workshop was affected and no cause could be assigned for the outbreak. On April 24th a case of meningitis was reported from barrack XII and on each of the succeeding three days another case was notified from the same building.

Table IV.

*Cases of Cerebro-Spinal Fever at the Lahore Central Jail, 1904*

No.	Name	Age	Date of admission	Date of attack
I	Jabbar	22	19th July 1902	24th April 1904.
II	Fauj Singh	20	24th March 1904	25th April 1904
III	Rasul Khan	18	3rd May 1903	26th April 1904
IV	Akbar . .	23	5th April 1904	27th April 1904

Of these four men, the three latter were actually employed together on bamboo work. The first case was employed in the garden, but slept in the bed next to No IV. Case No. III died after an acute illness on April 28th, and the autopsy revealed a purulent meningitis. The Superintendent then sent me an urgent telegraphic message which I received at Bhagalpur on the morning of the 29th. I arrived at Lahore on

May 1st. In attempting to ascertain the possible source of infection, the following facts were brought to light. During the previous month (March) a fatal sporadic instance of the disease was notified to me from the District Jail, which adjoins the Central Jail. There is a certain amount of daily intercourse between the two institutions; small parties of men bring oil and foodstuffs from the one jail to the other, but none of the prisoners noted above had been thus employed. Two of the men attacked had been less than a month in the jail. Case No. II was admitted from the jail at Amritsar exactly a month prior to his attack, while No IV had arrived twenty-two days previously from the Rawalpindi Jail, from which two fatal sporadic attacks had been reported in March. It is difficult to decide whence the infection was brought, but I am inclined to consider that although No IV was the last to be attacked, yet he possibly brought the infection with him from Rawalpindi and infected the others during his own incubation period. It is unlikely that the prisoners were infected within the Lahore Jail, which had been free from the disease for thirteen years. In 1889-1890 it was a badly affected area. Major Braide, the Superintendent, had, prior to my arrival, taken energetic measures to stamp out the disease, the barrack had been evacuated and disinfected, its inmates had been segregated; and the three surviving patients had been placed in a special separate building within the hospital compound. As their attendants were mixing freely with many of the other prisoners, I suggested the removal of the cases and their attendants outside the jail, and Major Braide was able to comply with this at once, as he had an available suitable building. Several months have elapsed since these measures were carried out, and not a single other case has occurred. Two of the patients recovered completely, the third case (II) lapsed into a marasmic state and died on July 21st. The above outbreak simulated in its incidence the "house epidemics" which have been recorded from Germany and other countries.

### *References*

- 1 Epidemic Cerebro-Spinal Meningitis. A report to the State Board of Health, Massachusetts, by Councilman, Malloy, and Wright. Boston 1898
- 2 Netter. "Cerebro Spinal Meningitis" article in Twentieth Century Practice of Medicine Vol XVI, 1900. Also in supplementary Vol XXI, 1903
- 3 Jaeger "Die Cerebro-Spinal Meningitis als Heereseuche" Berlin 1901
- 4 R. Bruce Low "Epidemic Cerebro-Spinal Meningitis" Transactions of the Epidemiological Society of London, Vol XVIII, 1898-99, pp 53 et seq
- 5 R. Travers Smith "Experiences of an Epidemic of Cerebro-Spinal Meningitis" Practitioner March 1903
- 6 Transactions of the Epidemiological Society Vol VII, 1888, pp 110 et seq



- 7 Twining " Diseases of Bengal." Calcutta 1839.
- 8 Morehead " Researches on Disease in India " 2nd edition, 1860
- 9 Maclean " Tropical Diseases "
- 10 Fayrer. (a) " The Climate and Fevers of India," being the Croonian Lectures for 1882.  
(b) Allbutt's System of Medicine, Vol. II, pp 293 et seq
- 11 Chever's " A Commentary on Disease in India." 1886
- 12 Vandyke Carter. " Spirillum Fever Synonyms Famine or Relapsing Fever as seen in Western India " 1882
- 13 Transactions of the Bombay Medical and Physical Society No VIII 1886
- 14 Dimmock " A Report on Cerebro-Spinal Fever with a history of its occurrence among the Convicts of the District Jail at Shikarpur Upper Sind." Received from Inspector-General of Prisons, Bombay
- 15 Annual Report of the Sanitary Commissioner with the Government of India for the years 1881—1902 inclusive
- 16 Bastian Quain's Dictionary of Medicine 1903
- 17 Moorhead " Cerebro-Spinal Fever in India " Transactions of the Indian Medical Congress Calcutta, 1894
18. Buchanan (a) " Cerebro-Spinal Fever in India " British Medical Journal, September 24, 1898  
(b) " Contribution to the Etiology of Epidemic Cerebro-Spinal Meningitis " Journal of Hygiene. April 1901
- 19 C R Stevens " A report on the Epidemic of Cerebro-Spinal Fever in the Bhagalpur Central Jail, 1899-1900
- 20 E A R Newman. " Report on Cerebro-Spinal Meningitis in the Bhagalpur Central Jail, 1900-1901 " Indian Medical Gazette, September 1902
- 21 W Henvey " Cerebro-Spinal Meningitis in Raipur Central Jail, 1900-1901 " Indian Medical Gazette, June and July 1901
- 22 E Harold Brown " Epidemic of Cerebro-Spinal Meningitis in Calcutta " Indian Medical Gazette, January 1901.
- 23 C H Bensley " Report on Cerebro-Spinal Meningitis in Mung Rasul Jail, 1901 " (Official Papers )
- 24 Jackson Official Records in the Office of the Inspector General of Prisons Bombay.
- 25 W H Orr's " Report on Cerebro-Spinal Meningitis in Famine Camps, Ahmedabad, in 1902 Received from Inspector-General Civil Hospitals, United Provinces
- 26 Official Correspondence with Inspector-General of Prisons, Bombay, received from the Inspector-General's Office
- 27 Dr Cecil Wall " On Acute Cerebro-Spinal Meningitis " from Vol 86 of the " Medical Chirurgical Transactions " 1903
- 28 T Stodart Indian Medical Gazette 1904

## II.—Clinical.

*Synonyms.*—The disease has received various names at different times The older ones, such as "petechial or spotted fever," "cerebral typhus," "malignant purpuric fever" and the like, founded on an incomplete clinical and pathological knowledge of the disease, are inappropriate and are only of historical interest In England and America it is

commonly known as "Cerebro-Spinal Fever" and this is its appellation in the Nomenclature of diseases. This name has been objected to by Dr. Rutter Williamson (1) on the ground that cases exhibiting no pyrexia whatsoever have been observed and in his clinical study of the disease he cited two such instances from his own practice. These cases are unusual and anomalous. Cerebro-spinal fever is a good name for the disease. The Germans have called the disease "Naekenstaar" or "Geniekrampf." The former, which denotes a muscular cramp of the neck, is a good name from a popular point of view in that it emphasises a constant and painful symptom; it is thus comparable to our name "lock-jaw" for tetanus.

*Definition.*—Epidemic Cerebro-Spinal Meningitis is an acute infectious disease associated most frequently with the presence of a particular microorganism, the diplococcus intracellularis, first identified by Weichselbaum in 1887. It is characterised by symptoms referable to a profound inflammatory infection of the central nervous system, there is generally pyrexia of an irregular type, cutaneous eruptions of a petechial or herpetic form are not infrequently present, while extensions of the disease to the ear and the eye leading to disorganisation of these organs are common complications. The disease is known to prevail sporadically as well as epidemically. The sporadic attacks are of great importance, as they doubtless form the links between successive epidemics, clinically they are apt to be overlooked, and confusion as to their exact nature will continue to exist until a complete bacteriological diagnosis of the exudate to be obtained by lumbar puncture becomes a matter of routine procedure. It seems very probable that the disease known as posterior basilar meningitis in infants is but a sporadic form of the disease, for the organism isolated by Still (2) is almost identical in its biological characters with those of the diplococcus intracellularis.

*Ætiology.*—*Predisposing factors.* *Age*—Most of the recorded cases have occurred in children and young adults. Moore, (4) Williamson, (5) and Brown (6) have noted the disease among children in India. It is a rare affection of persons over the age of forty, as is indicated in the following table:—

Table V.

*Age incidence of Cerebro-Spinal Fever.*

Authority	Under 40	Over 40	Percentage under 40
Councilman (7)	104	7	93 %
Leichtenstern (8)	100	11	90 %
Indian Jails	83	28	74 7 %

Councilman states that infants under one year, although very liable

to every other, are seldom attacked by this form of meningitis. Still and Grimshaw,(9) however, point out that, if posterior basic meningitis be included as a variety of the disease, the sporadic form is commoner in infancy than at any other period of life.

*Sex*—It would appear that males are more prone to this disease, at least among adults, but it must be remarked that the bulk of the statistics emanate from prisons, work-houses, and barracks, in which males preponderate. These statistics cannot, therefore, be accurately employed as data from which to draw conclusions as to the general population and this applies not only to sex, but also to age and other ætiological factors. Still and Grimshaw (9) state that in children the sexes are attacked equally, but among Councilman's cases out of thirty-five patients under the age of fifteen, twenty-two, or nearly two-thirds, were females. In India, Harold Brown (6) has observed attacks among female children, while Henvey records the solitary instance of an adult female prisoner being afflicted by the disease (10).

*Race*.—Apparently the disease does not exhibit any special proclivity for a particular race. Some of the Indian jail statistics would seem to indicate that the disease is more prevalent among Hindus, but these, it must be remembered, form the greater number of the prisoners.

*Environment*—In its epidemic form the disease displays a particular liability to attack the inmates of jails, barracks, and workhouses where large numbers of men are congregated; we must, therefore, consider the influences which life in these places brings to bear on the inhabitants and how these affect, if they do, the spread of the disease.

Overcrowding has always been given a very prominent place among these influences, but there is very little evidence to show that it exerts any marked effect on the progress of an epidemic. It is certain that in some instances it has contributed to the continued prevalence of the disease in a particular place. In Bhagalpur although, in the official sense of the term, overcrowding did not exist, yet it is noted by Newman that there were more attacks when the population of the jail reached a high figure. Malcolm Moore (4) in his paper on the subject emphasised the influence of this factor, but produced no evidence to support his contention. Along with overcrowding defective sanitary conditions have usually been coupled as an associate factor. In the older epidemics and especially in those which prevailed in towns both these conditions were undoubtedly present. But, latterly, outbreaks have occurred in institutions, which although not always perfect sanitary buildings, certainly exhibit a very high hygienic standard. At any rate, this holds good as regards Indian jails, for the inmates of these are living under conditions of health, which

contrast very markedly with those of the ill-ventilated and squalid huts and hovels which form their homes. The buildings in central jails, wherein most of the epidemics have occurred, are large barracks amply ventilated and well protected from the various climatic influences of the district in which the jail is situated.

It is possible, and indeed probable, that life in barracks and jails, with its rigid discipline and other restrictions, has a depressing effect on the subjects therein located, and this renders them more prone to conditions of ill-health than they would be were they living among the free populace.

Fourthly, there is the question of labour. It is not so much a matter of real hard work but of the physical exertion required to complete a given task of more or less severity within a prescribed time. This applies equally to military barracks and jails as indeed it does to most, if not, to all workhouses. The inmates, fearing punishment, often work harder than they ought to complete their allotted tasks. A mental as well as a physical strain is thus involved. Labour under these conditions must have a debilitating effect on the system and those who are compelled thus to work are rendered more liable to be attacked by any infective agent which may happen to be about.

Cases of cerebro-spinal meningitis following great physical exertion have been remarked more than once. In two of the most notable of Indian epidemics, those at Shikarpur (Sind) in 1884-85 and at Mung Rasul in 1901, the prisoners were employed on the very hard labour of canal digging, but in others such as those at Bhagalpur and Raipur, the prisoners were not engaged in anything beyond the ordinary forms of jail employment. A reduction of both the amount and the period of labour in the two former jails had not the slightest effect in arresting the disease, which would seem to indicate that labour has little, if anything, to do with its incidence.

There is also the fact that those who have become recently subject to the above conditions are more readily attacked by the disease than those who have, so to speak, become acclimatised to life in jails or barracks. In the French military epidemics it was noted that the recruits were more susceptible than were the old soldiers, and Newman has stated that prisoners recently admitted were more frequently attacked than those who had been in jail for some time. Rogers in his note on Newman's report has laid particular stress on this point, but it is indeed one that cerebro-spinal fever shares with all other infective disorders.

In conclusion, in the absence of any direct proofs as to where the infective agent exists in nature or as to how it gains an entrance into the human body, we can but state that the disease is one apt to affect a

locality and to remain there for a considerable, but variable time : it is further liable therein for reasons, possibly climatic but equally unknown, to periodic exacerbations.

*Occupation.*—This has already been partly discussed in connection with environment, but requires further consideration in view of the data brought forward by Buchanan, (13) who thoroughly studied the epidemics which occurred in his jail and who has endeavoured to show that a close relation exists between dust and the disease. Buchanan's theory is that dust is either the vehicle for the specific germ in a desiccated condition or that it acts only mechanically by injuring the air passages and thus diminishing resistance, presuming, of course, that infection occurs through the nares. To support this he adduces the following facts. He divides the occupations of the prisoners into two classes : in the first place, there are those engaged in non-dusty work, such as blanket-spinning and weaving, carpet-making, carpentering, tailoring, etc., which are conducted in light, well-ventilated buildings, and, secondly, there are those engaged in dusty occupations as rice-cleaning, rice-husking, wheat-grinding, road-sweeping, gardening, and other outside forms of labour. Of these latter, the first three certainly occur under conditions where the atmosphere is so clouded that the individuals in the shed can hardly be distinguished and a vivid impression remains in my mind of the scene in the wheat-grinding house at my visit in September 1902 when work was in full swing. Sweeping and gardening are rightly included among the dusty occupations when the seasonal conditions are remembered. From February until June the climate is a hot dry one, no rain falls and the roads and fields are covered with dust to a depth of two or three inches. During these months also, but especially in April, the phenomena known as "dust-storms" prevail. The whole atmosphere then becomes so thick with dust that the sun is often occluded from view for several hours; strong winds with thunder and rain always accompany this disturbance.

In the month of April when, as Buchanan states, these storms are of almost daily occurrence, the greatest number of attacks were observed by him in three outbreaks at this station. Moreover, in the months from June to October, when outdoor labour cannot be described as dusty, the seven attacks recorded by him during these months all came from the dusty wheat-grinding or rice-cleaning worksheds. In these the men were working under similar conditions to those which they would have experienced at any other time of the year.

Of the one thousand and eight hundred odd prisoners in the jail at Bhagalpur, one thousand and one hundred can be classed as being

more or less constantly on non-dusty employment, while the work of the remaining seven hundred is dusty. Of the forty-seven cases chronicled by Buchanan, only three occurred in the former group and no less than forty-four in the latter

Newman, (11) who succeeded Buchanan in charge of the Bhagalpur Jail, has brought forward additional evidence to support the possible significance of dust with regard to the disease. Classifying their occupations as did Buchanan, he found that of the forty-two attacks in the fourth and fifth epidemics, only nine came from those whose employment was non-dusty; and comparing the numbers of men employed on each form of labour during the period of prevalence, he showed that the disease was seven times more frequently observed in men employed on dusty work than in those on non-dusty forms of labour

Further evidence as to the possible connection between dust and the disease has been adduced by two other Indian writers as the result of their experiences, *viz*, Williamson (1) in the Bombay Presidency and Mactaggart (14) in the United Provinces. On the other hand, the Superintendent of the Mung Rasul Jail, while admitting that the occupation of the greater number of the prisoners, from which all but three of his cases came, was an exceedingly dusty one, would have expected more cases among those employed in the sweeping of the jail and among those engaged in scraping and cleansing the affected barracks. In this instance the jail was a new one and had been only recently occupied. The prisoners were all long-term ones and were transfers from other jails. There was no record of the existence of the disease among the surrounding free population, but it should be noted that these worked side by side with the prisoners and the latter might have become infected while at work

In the other Indian observations from Ahmedabad, (17) Raipur, (10) Mewar, (4) Hissar, (15) and Delhi, (16) the conditions of employment are not sufficiently specified to permit of any deductions being drawn

Buchanan and Newman have both quoted Germano's experiments as to the resistance of the *diplococcus intracellularis* to drying in support of their contentions, but as Nuttall in his editorial note on the former's paper has pointed out, Germano made no experiments to show that the organisms had retained their virulence. It is possible, however, that, like the closely associated organism of the same group, the pneumococcus, the *diplococcus intracellularis* may be capable of desiccation and of existing in a non-virulent saprophytic form in dust or in other similar material and that under suitable conditions it may become exalted in virulence. All this is purely hypothetical and until we can definitely

exhibit the organism in dust, we can but agree with Buchanan as to the strong presumption of some relation between dust and the disease

*Food, etc* — There is no evidence that either food or water have any connection with the disease. In 1865 Sir B. W. Richardson propounded a theory that the disease might be due to the consumption of diseased grain, but no proof of this has ever been brought forward. The only Indian reference to food having any possible effect is that of Dimmock, who at Shikarpur in 1884-85 thought that the dietary of the prisoners was insufficient in proteins and fats considering the seasonal conditions and the hard manual labour in which the men were engaged.

*Climate and seasonal prevalence* — The earlier records of the disease pointed to its incidence in temperate regions only, but the experience of the last twenty years has shown that it prevails also in the sub-tropics. It will probably be found that no latitude is exempt from its ravages, although up to the present no exact record has been found by the writer of its having been observed in Australia, Central or South America. With regard to Africa, an outbreak was reported from Omdurman after the fall of that city in 1898 (35), Miss Williams (36) recorded another from East Africa in 1900, and recently a sporadic case has been chronicled from the Transvaal (37). In India the disease has prevailed comparatively slightly south of the Tropic of Cancer.

Much stress has been laid on cold as a prominent predisposing factor, and attacks following exposure to intense cold have been described. In the earliest Indian epidemics (Shikarpur, Nara, etc.) and also in some of the later ones (Mewar, Rajpur, etc.) this influence was particularly noted, as all the attacks occurred in the cold weather when the night temperatures are very low. The epidemics at Bhagalpur, Miraj, and Mung Rasul, however, showed most attacks during the hottest weather when the day shade temperature varies between 90°F and 114°F, while the night minimal seldom falls below 75°F.

It would appear that the spring months (March, April, and May) are those which most favour the incidence of the disease. In India the large majority of attacks have been recorded during them. Buchanan is of opinion that the dust-storms, which prevail in these months, may possibly account for this frequency.

*Famine* — Dr. Williamson (1) has referred to this as a possible predisposing factor, for all the cases observed by him were among famine-stricken children in 1899-1901. In the Hissar and Delhi districts the disease was epidemic among the free population in the cold weather of 1901-02 following the famine of the former year. In the Ahmedabad district a similar condition of affairs existed, the disease is said to have prevailed

in the famine camps and in the villages, whence it was doubtless imported into the Central Prison in February 1902.

*Microbic factors*—In the next section of this report, the micro-organisms which have been associated with cerebro-spinal fever will be fully described. The most important of these, and the one, too, which most authorities have reckoned to be the sole causal agent, is the diplococcus intracellularis, discovered by Weichselbaum in 1887 in the meningeal exudates of sporadic instances of the disease. It is allied biologically to the better known microbe, the pneumococcus of Fraenkel, from which it is to be distinguished by its almost constant presence within the polynuclear cells of exudates, its more spherical shape, and by the fact that it does not retain the stain by Gram's method. The pneumococcus itself has also been declared by some to be a not uncommon ætiological factor in cerebro-spinal meningitis, and in some cases it has been recovered in association with Weichselbaum's organism. The latter is distinguished with greater difficulty from the gonococcus: they are alike in their morphological characters, neither retains Gram's stain, but they differ as to their power of growth on artificial media—the diplococcus intracellularis or meningococcus grows more readily on ordinary media such as agar-agar or glycerine agar—and as to their pathogenic effect on animals.

In sporadic attacks of cerebro-spinal fever, as well as in the epidemic ones, the meningococcus has been isolated from the meningeal exudates. It is possible that the organism described by Still, (3) as having been found by him in cases of posterior basic meningitis, will be declared to be identical with that of Weichselbaum. This would seem to be so judging by the observations of Dr Stuart Macdonald (23) and by those of Dr Hunter at the London Hospital (24). The cases cited by the former were all instances of basic meningitis in young children and from nearly every one he recovered a microbe agreeing in its biological characteristics with the meningococcus.

In India bacteriological examinations have only been made in a comparatively small number of cases. Drury isolated the meningococcus from several of the Bhagalpur patients and from at least two sporadic instances of the disease in the Medical College at Calcutta. Rogers identified it in another of the Bhagalpur cases and also in four of the coolies who were attacked in the Alipore emigration dépôt. Semple examined numerous specimens from the epidemic at Mung Rasul and found the diplococcus in nearly every one. Lamb was similarly successful in his investigations at Ahmedabad, but from the only case at Poona which came under his observation, he isolated the pneumococcus. Roberts at



Indoic has also cultivated the meningococcus from fluid obtained by lumbar puncture from a sporadic instance of the disease.

*Channels of infection* —It is generally considered that the nares are the common channels of infection and that the organism makes its way thence to the meninges through the cribiform plate. In those suffering from the disease the presence of the organism in the nasal mucus has been demonstrated. Schiff has stated that he has recovered the meningococcus from the nasal mucus of seven out of twenty-seven healthy persons. The experiments of Busquet, quoted at page 49, afford evidence of the possibility of infection occurring through the nares, but further proof of this is necessary.

*Symptomatology —Incubation period.*—The period of incubation has not been satisfactorily settled. Most writers have very few data to bring forward on this point, which would appear to have received more attention in India than elsewhere. Buchanan and Newman are both inclined to consider it to be very short—less than three days, but Harold Brown, who especially studied this question, is of opinion that it may be any period from one to five weeks, most cases occurring in the second or third week after possible infection.

*Types of the disease.*—Most observers have recognised certain well marked types or forms which this disease assumes. It must be remembered, however, that such a division is purely arbitrary, being based on the "intensity and duration" of the malady. Cases are constantly met with which cannot be classified under any one form. Councilman and his colleagues, while agreeing with this, think that for practical purposes it is as well to differentiate the instances of the disease, and accordingly they have described the following varieties —(1) Acute (including fulminant), (2) Chronic, (3) Intermittent. Unlike most other writers, they did not meet with any of the so-called abortive attacks. There has been some difference of opinion as to the cases which should be considered as abortive. Strumpel, (24) who follows Hirsch's primary classification of "siderans," "abortiva," "intermittens," "and typhoides," is of opinion that, in addition to ordinary mild attacks, whose onset and initial phases are very severe, but in whom the disease rapidly abates within a few days, should also be considered as abortive cases. Major Brown's "atypical" form, in the classification about to be given, corresponds exactly to those cases of Strumpel's. The fulminating or foudroyante variety, the most distinctive and remarkable of all, has, by most authorities, been defined as a separate type. It has been with regard to such forms as "intermittent," "remittent," "typhoid," "pneumonic," etc.,

so termed from their resemblance to the diseases they simulate, that most confusion has existed

The classification given by Brown (6) is the most comprehensive of all. He recognises the following types —

I Fulminating (Foudroyante) Marked by abrupt onset, intensity of symptoms, rapid coma and death within eighteen hours. As a remarkable instance of this variety the following case taken from Steven's Bhagalpur series may be quoted (30) —

Case XV Donau Roy, Hindu 24th April — Worked as usual and sat at evening meal without making any complaint, but did not eat much, at 8 P.M. he began to feel ill said he had fever, but refused to go to hospital, as it was slight. Shortly after he began to take long breaths with stertor, was brought to hospital and arrived there in a state of collapse, abdominal respiration only. Died at 9 P.M. Autopsy Fine leptomeningitis covering brain convolutions. Patches of lymph at base. A large amount of turbid fluid in the spinal canal.

II Acute Onset sudden. Symptoms rapidly become marked. Patient dies, as a rule, between the second and the sixth day. Mortality for this form very great, nearly eighty per cent. of those attacked succumbing to the disease.

III Subacute and chronic Onset more gradual, irregular remittent temperature. After two or three days meningeal symptoms become prominent. Rashes generally petechial are very common. The disease progresses very slowly and may last for weeks or months, death finally being due to exhaustion. Such cases are also comparatively fatal, the mortality being over sixty per cent.

IV Atypical and irregular Sudden onset with usual symptoms followed within one to three days by a "sudden amelioration of all symptoms," and the patient generally recovers. Major Brown met with six such instances of the disease.

Onset — The disease, in the great majority of attacks, commences abruptly. A person who up to the moment of attack or within a very few hours of it has been in good health is suddenly seized with intense headache, malaise, vertigo and vomiting, etc. When the onset occurs more gradually, the symptoms simulate those of other acute diseases, and early diagnosis is a matter of some difficulty, but even in these, as Wall (24) points out, when the distinctive signs of the disease come on, they advance rapidly, in marked contrast to those of tubercular meningitis, with which they might be confounded. The proportion of cases in which the onset is sudden is, according to Stevens, about one-third of the attacks. This estimate is rather low and in most epidemics

the majority of the attacks commenced abruptly. This is especially noticeable at the beginning of an epidemic. Out of Henvey's first fourteen cases at Raipur, in nine was the onset sudden. No less than six belonged to the fulminating type and only one of the fourteen recovered.

*Clinical Course.*—The patient, who has been attacked by cerebro-spinal fever, first complains of severe headache, which he refers to the occipital region. Malaise with increasing pyrexia soon become prominent and very frequently nausea and vomiting are present. The pain referred to the head has now also extended to the back and limbs. The patient's mental condition is depressed. He lies on his side with his head firmly retracted and with his knees drawn up. His condition is one of cerebral irritation and he resents interference of all kinds. He is intolerant of light. If the case is of the fulminating type, the patient will become rapidly comatose and death soon terminates the scene. In an ordinary acute case the symptoms progress more gradually. An irregular pyrexia, various paralyses, herpetic eruptions about the lips, and, in some cases, rashes over the body of a petechial nature, are to be observed. The mental condition varies: for brief intervals the patient recovers a certain amount of consciousness and makes complaint of his painful condition. On the third or fourth day he may appear to be distinctly better, but such hopes as may be raised by this temporary improvement are soon abandoned. The meningeal symptoms recur with accentuated severity. Consciousness is soon lost and the patient becomes comatose, in which condition he may linger for a day or two before death occurs. Instances of recovery even after this stage of coma has been reached are known, but are distinctly rare. If the patient is to recover, the stage of coma is not attained. In less acute attacks the disease pursues an irregular course. With a gradual onset the initial malaise may extend over two or three days before meningeal symptoms are apparent. These are less severe than in the other forms, but, nevertheless, the patient appears to be profoundly ill. An irregular pyrexia with all its concomitants of anorexia, wasting and general depression are present. Petechial rashes are frequently seen. The nervous symptoms may continue in comparatively mild fashion or they may be present in the form of alternate exacerbations and more or less complete remissions. Such a state of affairs may extend over several weeks: at any time during its course the patient may succumb either from the severity of the meningeal symptoms or from the exhaustion which such an illness entails, or he may recover, his convalescence being a tardy one. Complete recovery does not always take place, loss of vision, deafness or paresis of the limbs may remain.

*Pyrexia* — Although not a constant symptom, pyrexia is but rarely

absent Strumpel records a fatal case in which the temperature was sub-normal throughout and Williamson has treated similar cases in India. The pyrexia follows no definite type. It is irregularly remittent and a remarkable feature of the fever is that it bears little or no relation to the other symptoms. For the temperature may be high and the pulse normal, an exacerbation of the nervous symptoms is not necessarily accompanied by a rise of temperature. The temperature varies between  $98.4^{\circ}$  and  $104^{\circ}$  F. Hyperpyrexia is not common. It is said to be more often seen in children. Several of Henvey's cases exhibited high initial temperatures ( $105-106^{\circ}$  F) but this has not been observed by others.

*Pain*—Headache is a constant initial and often a persistent symptom of the disease. It is directly due to inflammation of the meninges. As this extends and as an exudate is formed, we get further pains referred to the face (of a neuralgic nature), to the spine and more rarely to the limbs. The initial headache is commonly occipital, but may be frontal. It soon becomes generalised. Its character is always acute. Constantly present and equally trying is pain referred to the back of the neck. This is always marked and any attempt at movement of the head invariably adds to the suffering of the patient.

A prominent feature of all cases, especially the acute ones, is a general cutaneous hyperæsthesia. In every Indian epidemic this has been noted and Williamson has stated that in three of his patients (boys) the lightest stroke of the skin caused the sufferer to cry out.

*Rigidity of the neck and retraction of the head*—These are among the most characteristic symptoms of the disease. They are invariably present in some degree, and persist throughout, being among the last signs to disappear. Both are assumed to relieve pain. As many writers have declared, the rigidity of the cervical muscles is not a true muscular spasm. Wall considers that it should be regarded as resistance to forward flexion of the head. The head can be rotated, but can only be flexed to the evident discomfort of the patient. The retraction of the head is sometimes so great as to be better designated "Cervical Opisthotonos." This is seen in children, in whom, also, spinal opisthotonos has been observed.

*Vomiting*—This is a frequent initial and a not uncommon late symptom of cerebro-spinal meningitis. It is usually considered to be of cerebral origin, but this is not always the case as Williamson has pointed out. Both in the early and in the late stages of this disease this symptom, when cerebral, is mainly the result of increased intracranial pressure consequent on the deposition of inflammatory exudate. That this is probable is shown by the fact that lumbar puncture and the withdrawal

of a quantity of fluid will often relieve this distressing and even alarming condition.

Councilman and his colleagues have stated that this symptom is to be observed in seventy per cent of those attacked. A similar frequency has been noted in India by all writers except Moorhead, (27) who has pointed out that this symptom was absent in every case seen by him at Hazaribagh.

The nature of the vomit has not been remarked by authorities outside India. Dimmock (28) states that the vomit was of a vivid light-green colour, and Bensley (29) reports the same from Mung Rasul. Brown (6) also notes that at Alipui in acute cases the vomit and the fæces were of a greenish colour.

*Psychical Disturbances.*—Vertigo is often observed at the beginning of an attack. A general depression of mental activity, accompanied by more or less irritability, gives way to delirium, which is of the low muttering variety, it is often periodic in character, alternating with phases of partial coma. In fatal attacks deep coma is present, often very early in the course of the disease. Insomnia and other mental disturbances are more rarely observed. In some of the cases which have recovered an altered mental condition, mania, or more commonly melancholia, has been recorded. I saw a patient afflicted with acute melancholia after cerebro-spinal fever at the Bhagalpur Central Jail in April 1904.

*Kernig's symptom.*—This symptom, which was first discovered in connection with this disease by Kernig, a Russian physician, was formerly thought to be pathognomonic. Later researches have proved that it is common to all forms of meningitis, and it has been elicited in patients suffering from other diseases. The sign consists in a spasm of the flexors of the knee. It is induced when the patient is recumbent by flexing the thigh on the abdomen and then attempting to extend the leg. If the patient can be made to sit up in bed, it will be observed that the knees are in a position of semiflexion, attempts at full extension meet with resistance. According to Buchanan, a similar spasm of the flexors of the elbows occurs.

*Other nervous symptoms*—The nervous symptoms less constantly met with in cerebro-spinal fever involve chiefly the motor area. They are pareses and paralyses of every degree and extent: tonic and clonic spasms equally variable and occasionally simulating true epileptic seizures, or appearing as convulsions in children: contractures of the extremities, etc. Of the paralyses, the most common are those in connection with the ocular movements and will be referred to later. Facial paralysis comes next: it may be unilateral or bilateral, complete or incomplete.

Dimmock remarked this symptom in fulminant cases, Stevens and others have also recorded instances of it. Monoplegias, hemiplegias, and paraplegias have likewise been chronicled but are all distinctly rare. Paralysis of the bladder has been met with in some cases. Of tonic spasms, trismus is not uncommon, but it is never so complete as in tetanus.

*Cutaneous eruptions*—Cutaneous affections are remarkable in that they have been more frequently recorded in some epidemics than in others. So much has this been the case, that popular names, to denote this character, such as "spotted fever" and the "black sickness," have arisen. An excellent historical summary of the presence or absence of these in various epidemics is given by Councilman (7). In the outbreak, which he himself observed, they were not so common, herpes, chiefly labialis, was noted in thirty-five cases, and petechial conditions in eleven out of a total of one hundred and eleven. Thirteen patients, out of twenty-one attacked, were observed by Osler (19) to exhibit skin affections. In India skin eruptions have been still more rarely recorded: several writers do not mention them at all, while others state that they occurred in only one or two of their patients. Dimmock (28) notes one case in which a petechial eruption persisted. Dadachanji (31) says that, in four of his thirteen cases, small livid petechial spots were to be observed on the chest and abdomen. Stevens (30) met with herpes labialis in about one-fifth of his cases. Brown (6) states with reference to acute attacks: "In such cases I have observed herpes on the lips, but never any other kind of rash for, as far as my experience goes, petechial and other rashes do not occur until later in the disease. Every acute case was examined most carefully for a rash, but in no case was one discovered (apart from herpes) of the patient died within the first week." According to the same writer, in sub-acute and chronic cases after the first week, petechial eruptions are very common. The petechiae enlarge to "maculae, the size of split peas, which in time cover the patient from head to foot as if he had a severe attack of small-pox." Brown also notes a case in which the marks were peculiarly persistent.

Herpes and purpura are, therefore, the commonest skin affections in this disease. Various others have been noted, such as erythema, pemphigus, urticaria, ecchyma, etc, but of these latter I have found no record in Indian reports, nor has the presence of lenticular rose spots, such as are found in enteric, and described first in this connection by Toudes, (32) been observed.

A remarkable feature of the eruptions is that they are usually bilateral. Herpes most commonly attacks the lips and face, being seldom seen outside the distribution of the fifth nerve. It generally

appears about the fourth day, but has been noted later than this. Purpuric eruptions appear as small livid spots (petechial), which later increase in size and become macular or even papular. The body may be covered by such an eruption, but in most cases its distribution is limited to the chest, abdomen, or one or both extremities, most writers have declared that purpura is an early feature of the disease, appearing as soon as the third day, often coincidently with herpes, but as already noted, at Alipur it was a late symptom chiefly affecting sub-acute cases.

Osler records a diffuse livid erythema near the extensor surfaces of joints in three cases followed by purpuric herpes. In a sub-acute fatal case, recently reported to me from Dehra Ghazi Khan, which I diagnosed bacteriologically, the following cutaneous conditions were observed. About the fifth day a diffuse erythema of the chest appeared, herpes of the tongue and mucous membrane of the mouth were noted on the sixth day: on the seventh a patch of herpes appeared over the sacrum and the erythema had extended to the back the erythema persisted. On the sixteenth day petechial streaks appeared about the right knee-joint on the side opposite to that which had been punctured three days previously.

*Affections of the eyes*—The eyes are very commonly affected in cerebro-spinal fever and of a variety of ocular conditions which may be present, alterations in size and mobility of the pupils and mild conjunctivitis are most frequently met with. Other lesions such as keratitis, choroiditis, and optic neuritis are so rare as to be better considered as complications. The involvement in the exudate of the cranial portions of the third, fourth, and sixth nerves accounts for the frequency of the ocular and pupillary paralytic symptoms noted. Strabismus may be either convergent or divergent, the former being perhaps the commoner of the two. In twenty-one of Councilman's cases, which exhibited this symptom, thirteen were of the convergent and eight of the divergent type. Dimmock also considered the squint to be more frequently convergent. Pupillary contraction or dilatation, irregularity or fixation, are due to the same causes and are similarly variable. A mild conjunctivitis is not uncommon in acute and sub-acute cases. It is due, as are more severe affections of the cornea and conjunctiva, to implication of the fifth nerve and its ganglia. In the records of Indian cases, which I have seen, less attention has been bestowed on ophthalmic conditions than would have been expected. For those interested in this matter, the best and fullest account of ocular and auditory conditions is that given by Councilman. (7)

*The Blood*.—A marked leucocytosis, mainly polymorphonuclear, is always present. As Osler (19) points out, it reaches a much higher figure

—40000 per c. cm.—and is more persistent than in such other forms of meningitis as the tubercular.

*The Pulse*—Councilman writes: “The pulse shows the same irregularity as the temperature and in all epidemics observers have agreed that there is no relation between the pulse and the temperature such as is seen in acute febrile diseases.” The pulse is slow and is frequently irregularly intermittent. In fulminant cases, where there is considerable circulatory depression, it is, according to Dimmock, weak and thready.

*Complications, sequelæ, etc*—The most important complications of cerebro-spinal meningitis are those relating to the lungs, the joints, and the auditory and visual senses. Of the pulmonary affections bronchitis and bronchopneumonia are frequently met with, especially in children. Lobar pneumonia has been erroneously considered a common complication of cerebro-spinal meningitis due to the meningococcus, but Councilman points out that this is not the case, and that confusion has existed between the cases in which the pneumococcus, and those in which Weichselbaum's diplococcus was the ætiological factor. Netter naturally states that pneumonia is a very frequent complication, but as he includes cases due to both organisms in his category of cerebro-spinal meningitis, this is to be expected. He does not definitely say whether in cases from those meningeal exudates the meningococcus was recovered pneumonia was frequently met with as a complication. In about ten per cent of the Indian cases a pneumonic condition has been observed. Dimmock has stated that lung affections, chiefly pneumonic, were not infrequent. Out of eleven cases reported by Dadachanji, in two of them were pneumonic symptoms observed. Of Moorhead's sixteen patients, six showed respiratory affections, one exhibiting a true lobar pneumonia. Stevens in his careful record of the Bhagalpur cases—altogether about twenty-one—reports that in all the fatal cases the lungs were found to be engorged, but in only two were there evidences of pneumonic consolidation. Buchanan, remarking on the same cases and on twenty-six additional ones, states that in the whole number only three showed pneumonic affection, and he adds that there is no prevalence of pneumonia while these cases were occurring. Five of Bensley's first thirty-eight cases at Mung Rasul were complicated with pneumonia. In the second outbreak in which twenty-two men were attacked, a similar proportion of pneumonic implication was observed, although pneumonia was extremely prevalent in the jail at the same time. It is to be regretted that these cases were not more fully investigated bacteriologically.

An acute inflammation of one or more joints, which may be either an



arthritis or a polyarthritis, has been an interesting feature of several cases in some epidemics, mild degrees of joint implication, such as rheumatic pains or slight swelling of one or more joints, are very common, as indeed they are in many febrile conditions. In the Shikarpur and Mung Rasul epidemics, joint affections were frequently observed, in the former Dimmock was inclined to consider the disease on this account allied to acute rheumatism. At Bhagalpur there have been several cases of acute arthritis; Stevens recorded one and Newman three, in one of which death, on the fifty-seventh day, was ascribed to pyæmia following the joint affection. In the sporadic case at Dehra Ghazi Khan, whose cutaneous condition I have described, both knee-joints were involved. Lieutenant Nutt, in charge of the patient, aspirated the right joint and sent me some of the semi-purulent fluid he obtained. By plate cultures on glycerine agar I recovered from this pure growths of Weichselbaum's diplococcus. The pathological relation of joint affections to the disease has not been defined.

The common ophthalmic conditions have been already dealt with. An extension of the inflammatory process along the sheaths of the optic nerve to the eyes has led occasionally to purulent choroiditis and iritis and sometimes to suppurative panophthalmitis. I have seen a case of the latter, but of the former I have found no record in India. Williamson (1) and Henvey (10) have both observed optic neuritis. Jack noted this in six children and considered that it occurred fairly frequently. (7) In the London Hospital series recorded by Wall, (24) in most of which the fundi were carefully examined, in only two out of twenty-two were there any evidences of neuritis. An important point in relation to ocular complications is that they are generally unilateral, while auditory ones are more usually bilateral. Of auditory affections deafness, which may persist, is of frequent occurrence. Suppuration of the middle and internal ear has also been noted. Bensley (29) is the only Indian observer who refers to this condition.

Contrary to expectation, and especially as they are considered the channels of infection, acute or chronic nasal conditions are exceedingly rare. Councilman notes one case of acute coryza and three in which an initial epistaxis took place.

Deafness, impairment or loss of vision, mental enfeeblement, and various paralyses are the chief sequelæ of the disease.

Relapses, almost invariably fatal, have been occasionally reported. Stevens notes one on the seventeenth day of the patient's illness, while Bensley treated three such cases.

Second attacks are very rare. Councilman has collected five instances

of this from the literature of the disease up to the date of his report (1898) They have not been recorded in India

*Mortality* — Cerebro-spinal fever, as Osler remarks, is one of the most fatal of all known diseases In most epidemics a very high death-rate has occurred In some, however, this has been exceptionally low, only twenty or thirty per cent of those attacked having succumbed; but this is quite exceptional Rollet (33) has computed the mortality of a large series of epidemics in France to be fifty-one per cent. In the Boston epidemics it was 68.5 per cent and the average of five Indian outbreaks works about the same figure, 68 per cent, as is shown in the following table :—

Table VI.

*Mortality.*

Observer	Place	Year	Cases	Deaths.	Mortality
Dimmock (28)	Shukarpur	1883	38	27	71 per cent.
Buchanan (13)	Bhagalpur	1897-1900	47	32	68 per cent
Eensley (29)	Mung Rasul	1901-1902	67	42	62 per cent.
Brown (6)	Alipur	1900-1901	53	36	68 per cent
Newman (11)	Bhagalpur	1900-1901	42	30	71 per cent
			247	167	68 per cent.

*Pathology and morbid Anatomy*—A large number of pathological examinations have been made in Indian jails, the gross lesions observed have been recorded, but, as far as I am aware, no minute study of the tissues involved has been made In the monograph by Councilman, Mallory and Wright, (7) to which I have had so frequent occasion to refer, the morbid anatomy, macroscopical as well as microscopical, is treated with a completeness and an accuracy which makes that work the standard reference in this connection.

The exact pathology of the disease has not yet been determined The chief lesion is an inflammatory one of the pia-arachnoid of the brain and the cord due to the presence of micro-organisms, these form locally a toxin of varying strength, intense in the fulminant, less active in the other cases. Other lesions, such as patches of pneumonic consolidation in the lungs, purulent arthritic effusions, suppurative otitis or panophthalmitis, etc., are the result of extensions of the inflammatory process either direct or by way of the lymphatics. Until quite recently

the meningococcus had never been isolated from the circulating blood during life nor from the circulatory system after death, but Warfield and Walker report having accomplished this (34) Confirmation of their work is, however, required, for all previous investigators had failed to demonstrate the presence of the organism in the blood or in the tissues, other than those referred to That the organism must in some cases pass into the circulation is certain, for it would be otherwise difficult to explain such lesions as arthritis which have been shown to be bacteriologically identical with the meningeal affection

*Morbid Anatomy* —The macroscopic and microscopic pathological changes of this disease are almost entirely confined to the central nervous system They exhibit great variations, depending on the intensity and duration of each particular case The following summary of them is chiefly taken from Councilman's report

*Lesions of the Nervous system* —There is an acute inflammation of the pia-maternal, together with the formation in these membranes of an exudate whose character may vary from being serofibrinous to being purulent This exudate commonly exhibits the following distribution It is present at the base of the brain between the optic commissure and the medulla a deposit of it is almost always found on the convexity covering the lateral parts of the parietal and temporo-sphenoidal lobes but rarely approaching the superior sinus the cerebellum is bathed in inflammatory material and the cord is in a similar condition, its posterior surface generally exhibiting a greater amount than the anterior Gravity and to a certain extent anatomical conditions account for this The appearances in the pia-maternal in the different types of the disease exhibit an increasing intensity with duration Councilman (7) was unable to obtain an autopsy in any of his fulminant cases, but C R Stevens (30) has recorded the changes he observed in six such fatal attacks The patients died at intervals from one to forty-two hours after attack and the following is a brief summary of his observations :—

“After one hour Fine lepto-meningitis · small patches of lymph at places

“After four hours Convolutions covered with fine cloudy lepto-meningitis · yellow purulent matter here and there filling the sulci. Large quantity of yellow turbid fluid in the spinal canal Reddish fluid in ventricles Brain much congested

“After six hours Brain covered above and below with yellowish-green pus. Brownish fluid filling the ventricles

“After nine, thirty-two and forty-two hours similar but more marked condition, increasing with duration.”

The same writer observes that, in acute cases, dying between the second and the fourteenth day, there is always a yellowish-green purulent exudate, varying in extent and amount in individual instances. The ventricles and the spinal canal are full of turbid fluid; the quantity in the latter is often remarkable. In chronic cases a good deal of pus may still be seen in some instances, but fibroid changes in the membranes have generally become established.

The dura mater shows no marked change as a rule. Its vessels may be engorged. In chronic cases a certain degree of thickening is to be observed.

Microscopically the pia-arachnoid, in the interstices of its connective tissue network, exhibits, in the earlier cases, an infiltration of leucocytes of the polymorpho-nuclear variety, frequently crowded into masses. These cells contain, in greater or less number, characteristic diplococci, which are also to be noted outside them. In later cases the cells have increased in number and have become granular pus cells. In addition to these granular cells, there are other large "giant" cells (called "Plasma cells" by Unna), which are especially to be seen in chronic attacks. These cells Councilman and his colleagues have shown to be derived from the normal connective tissue cells lining the lymph spaces of the meninges. They are about two to eight times the size of ordinary leucocytes with large nuclei and a granular protoplasm. Inside them polynuclear leucocytes may be seen. The fluid part of the exudate is always fibrinous, but never so markedly as in some other forms of meningitis such as the pneumococcic.

The vessels are dilated, occasionally thrombi are found in them but proliferative changes in the intima are rarer than in other forms.

In very advanced cases the pia-arachnoid is converted into thick cicatricial-like tissue, while the exudate, if present, consists of degenerate pus cells and a few large ones.

The substance of the brain and spinal cord rarely shows any gross changes. Hæmorrhages have been observed in the latter. The ventricles of the former are usually dilated with an excess of fluid more or less similar to that forming the meningeal exudate. In cases dying after the fifth day, certain microscopic changes are to be observed in the brain and cord. These are more frequently met with in meningitis due to the meningococcus than in any other variety. They consist of a purulent infiltration from the meningeal exudate into the substance of the brain, chiefly but not entirely along the track of the vessels. The infiltration involves the outer layer of the cortex and seldom penetrates to the layer of ganglion cells or the white matter. Minute hæmorrhages, appearing

microscopically in combination with purulent infiltration and surrounded by neuroglial proliferative changes, were also observed. The nerve cells in the parts affected had increased in number, they had also become large and irregular and their nuclei occasionally exhibited evidences of proliferative activity. Such changes were apparently confined to the cerebral cortex and were only found once in the cord. The nerve fibres were degenerated and changes were also noticed in the ganglion cells.

The cranial and spinal nerves and their ganglia when involved in the exudate, are always swollen and inflamed. These changes consist in a purulent infiltration with an increase in the cellular and neuroglial elements. They were most marked in the second, fifth, and eighth cranial nerves. The Gasserian ganglia in five cases were similarly affected. The pituitary body in two instances showed purulent infiltration. In a case, fatal on the seventh day, a purulent extension along the optic nerves to the coats of the eye involving the cornea but not the sclerotic was found on section, a similar but less advanced condition had been noted in an earlier case. One case out of three examined showed purulent infiltration of the nasal mucous membrane.

The pathological changes found in other organs are neither constant nor important. The heart and vessels are rarely affected. In some epidemics pericarditis and endocarditis have been complementary features. Of Moorhead's twelve patients at Hazaribagh, ten exhibited pericarditis with effusion (27), a similar condition was reported by Henvey to be present in three of his cases at Raipur (10). Endocarditis has not been recorded in India, but a note of a case where this was proved to be due to Weichselbaum's meningococcus has recently been published in America (34).

Next to the nervous system, the lungs are most commonly the seat of morbid changes. Congestion with oedema, lobar and lobular pneumonia are the conditions met with. Congestion has been noted by most Indian writers, but lobular pneumonia, which is generally due to the presence of the meningococcus, has been seldom observed. Connelman in eight such cases isolated this organism and in seven others, which he saw, it might have been the ætiological factor. Lobar pneumonia in its varying stages has been, as already stated, observed in about ten per cent of the cases.

The other organs of the body are still more rarely involved. Pathological conditions found in these were probably present prior to the meningeal attack.

The cutaneous and arthritic conditions have not been sufficiently studied pathologically to permit of any deductions being drawn therefrom.

*Diagnosis* —When epidemic, the diagnosis of cerebro-spinal fever in its fulminant and acute forms, should present no difficulty. The sudden onset of severe cerebral symptoms and the rapid collapse form a distinctive clinical picture. Influenza in some of its types and the septicæmic variety of plague in its initial stages are liable, however, to be confused with it. The former is the much more difficult ailment to differentiate and recourse must be had, in most cases of doubt, to lumbar puncture, the only satisfactory diagnostic procedure. With regard to plague, not only its septicæmic variety but also its other forms have been confused with cerebro-spinal fever. I am unable to understand why this should have been so, for, having seen many hundreds of cases of plague and not a few of cerebro-spinal fever, I have not met with a single case of the former which exhibited the intense meningeal symptoms of the latter.

Subacute and chronic cases have to be chiefly distinguished from typhoid (enteric) and typhus fevers. In the former, the prominence of the abdominal symptoms, the typical eruption and Widal's test would settle the diagnosis. As to typhus, much less has been heard of this disease during recent years in India. The course of the disease and the constant presence of a typical exanthem would distinguish typhus, which would also probably be prevailing in a more markedly epidemic manner.

The difficulty of diagnosis in India, as in many other countries, is enhanced by the fact that patients are seen for the first time in an unconscious or moribund condition. A complete autopsy would clear up such instances, but except in jails and for medico-legal purposes, it is not always possible to obtain this.

For the exact diagnosis of the particular ætiological factor involved, a bacteriological examination of the material obtained from the spinal canal during life or after death is required. Such, however, being neither practicable nor possible in every case, some mention must be made of the features of meningitis due to other organisms than the meningococcus.

Osler has constructed a tabular classification of cerebro-spinal meningitis based on bacteriological diagnosis —

Table VII.

*Osler's Classification of Cerebro-Spinal Meningitis.*

Primary	{	(1) Cerebro Spinal fever	{	(a) Sporadic	}	Meningococcus
				(b) Epidemic		
	{	(2) Pneumococcic	{	Meninges alone or part of general infection	}	Pneumococcus

Secondary	{ (1) Tubercular		B Tuberculosis
	{ (2) Pneumococcic	{ (a) Secondary to Pneumonia, (b) Secondary to ear or bone disease	{ Pneumococcus
	{ (3) Pyogenic	{ (a) Secondary to local disorder (b) Terminal affection in chronic diseases.	{ Staphylococci Streptococci
	{ Miscellaneous, Typhoid, influenza acute infections, Gonorrhœa, etc		{ The specific organisms

Of these conditions the most frequently met with, other than cerebro-spinal fever are tubercular and pneumococcic affections. But it should be observed that mixed infections are not uncommon. In seven of Councilman's series (7) the pneumococcus was isolated in addition to Weichselbaum's organism. Of thirty-eight cases observed by Wall at the London Hospital in 1901, (24) from all of which the meningococcus was isolated by culture, in only twenty-two was it the sole factor, in seven it was associated with the tubercle bacillus, in four with pyogenic organisms, in three with the bacillus of influenza, and in two with the pneumococcus.

The clinical distinctions between the tubercular meningitis and that caused by the meningococcus are that the former is invariably secondary to lung, bone or gland disease, that the meningitis comes on insidiously during a period of ill-health due to the primary condition, and that the symptoms referable to meningeal affection are less constant and less severe.

From primary pneumococcic meningitis the diagnosis is a matter of considerable difficulty. In the secondary forms, though easier it is not always thus, for the primary focus in the lung or middle ear may be obscure. From the very few instances accurately recorded it is only possible to say that in cerebro-spinal fever the symptomatology is more extensive and more complete. In the pneumococcic variety cutaneous conditions are never present, while ocular symptoms are rare. Pathologically, in both the gross appearances are similar, but in the pneumococcic exudate there is more fibrin, fewer large cells, and always a marked endarteritis of the pial vessels.

Councilman observed eight cases of secondary streptococcic meningitis. Such instances can only be bacteriologically diagnosed from either the pneumococcic or the epidemic form. They simulate the former clinically and pathologically.

It must thus be observed that an exact diagnosis of the particular

ætiological factor during life is only possible by having recourse to the method introduced by Quinke and known as "lumbar puncture". This operation is neither difficult nor, if carried out with due care, a procedure fraught with danger. An antitoxin needle, or a trocar and cannula, 5-8 cm (2-3 inches) in length, one mm in diameter, and a few sterile test-tubes are all that is necessary. The patient is placed on his left side with his knees drawn up. The interspaces between the lumbar vertebrae are made out and that between the second and third, or between the third and fourth, chosen as the site of puncture. The skin over this area and the hands of the operator are carefully cleansed in the usual manner. The needle is sterilized by boiling in five per cent carbolic acid for fifteen minutes. The needle, guided by the thumb of the left hand, which is pressed into the selected interspace, is entered at a point about half an inch to the right of the middle line, and is pushed in a direction inwards and slightly upwards until it reaches a depth of one and a half to two and a half inches. Fluid from the subarachnoid space will then exude and ought to be allowed to drop into one of the sterile tubes which has been carefully opened. Ten to fifteen cubic centimetres are required for bacteriological diagnosis, but much larger amounts have been withdrawn for therapeutical purposes. If any obstruction is met with during the passage of the needle, it should be withdrawn slightly and pressed more towards the median line. If blood exudes, a drop or two at first may be neglected, it is better to take out the needle and make another puncture in the space above. Fluid, which varies from being opalescent to being deeply purulent, is generally obtained, but in late cases nothing may come out, the exudate being scanty or too thick to pass through the needle.

### Treatment.

No drug occupies the position of being a specific for the disease, and treatment must therefore be directed towards the relief of symptoms. A variety of sedatives and analgesics have been more or less successfully employed to alleviate the painful initial stages. Morphia is the most useful of these and large doses of this drug are tolerated by the patients. Of others potassium bromide, exalgin, antipyrin, and aspirin have, in various cases, afforded relief. Local applications of ice-bags to the head, neck, and spine are also of value. Netter, who has had a very large experience of the disease, strongly advocates the employment of prolonged hot baths, he places the patient in water heated to 104° F for from ten to twenty minutes four or five times daily, while the acute symptoms persist. Others are also in favour of this measure.



Constant careful nursing and light nutritious food are essentials. Hyperpyrexia and other complications must be watched and treated should they occur.

Opinion is divided as to the value of lumbar puncture as a therapeutic measure. Netter, who formerly was inclined to discredit it, is now of opinion that it is a useful method of treatment. He says it not merely diminishes tension, but it withdraws a considerable number of pathogenic agents and thus increases the powers of defence of the organism. Puncture should be repeated at more or less close intervals during the course of the meningitis. The progress of the disease, the appearance or the reappearance of new symptoms (rise of temperature, changes in pulse, vomiting) will determine the necessity for puncture. Except as a diagnostic aid, others will not admit its utility and some are strongly opposed to it. In India Brown has employed it in four cases with considerable relief to the patients, in the cases I have done an amelioration of the symptoms followed the operation in all but one instance.

### Clinical.

### References

- 1 J Rutter Williamson "A clinical study of Epidemic Cerebro-Spinal Meningitis with especial reference to symptomatology and treatment" Calcutta 1901
- 2 G F Still "The Bacteriology of Simple Posterior Basic Meningitis of Infants" Journal of Pathology and Bacteriology, 1898
- 3 G F Still Note inserted in article by Lees and Barlow in Allbutt's System of Medicine, Vol VII, 1899
- 4 C M Moore Indian Medical Gazette, April 1902
- 5 Rutter Williamson Indian Medical Gazette, March, 1902.
- 6 Harold Brown Indian Medical Gazette January 1901 Bacteriological note on Brown's paper by L Rogers in same paper
- 7 Councilman, Mallory, and Wright "Epidemic Cerebro Spinal Meningitis" Boston 1898
- 8 Leichtenstern Deutsche Medicinische Wochenschrift, 1885
- 9 Still and Grimshaw Quain's Medicine 3rd edition, 1902
- 10 W Henvey Indian Medical Gazette September 1902 and Official Report
- 11 E A R Newman Official Report, 1903
- 12 L Rogers Appendix to Official Report by Newman, No 11
- 13 W J Buchanan. Journal of Hygiene, April 1901
- 14 Mactaggart British Medical Journal, September 4, 1901
- 15 Official Reports from Civil Surgeon, Hissar April and November 1902
- 16 Official Reports from Civil Surgeon, Delhi April and May, 1902
- 17 Official Reports from Superintendent, Central Jail Ahmedabad 1902
- 18 Stille (Pepper's System of Medicine Vol I) quoted from Williamson's clinical study (No 1)
- 19 W Osler British Medical Journal June 24, 1899.
- 20 W H Orr Official report received from Inspector General of Civil Hospitals United Provinces, 1903
- 21 Netter Twentieth Century Practice of Medicine Vols XVI and XXI

- 22 Jaeger "Die Cerebro-Spinal Meningitis als Heereserkrankung" 1901
- 23 Stuart Macdonald British Medical Journal July 12, 1902
- 24 Wall "Medico chirurgical Transactions" Vol 86, 1903
- 25 Schiff Centralblatt für Int Medical 1898
- 26 Strumpel "Lehrbuch 1889 D Arch Vol 30" (quoted from Councilman's Report)
- 27 J Moorhead Transactions, Indian Medical Congress, 1894
- 28 H F Dimmock Official Report to Inspector-General, Sind Circle, 1884
- 29 C H Benslev Official Reports, 1901 and 1902
- 30 C R Stevens Official Report, 1900
- 31 Dadachanji Transactions of Bombay Medical and Physical Society Vol VIII, 1886
- 32 Tourdes "Histoire de l'épidémie de la Cerebrospinal" 1842
- 33 Rollet "De la Meningite" 1841
- 34 Warfield and Walker Bulletin Ayer Clinical Laboratory of the Pennsylvania Hospital No 1, October 1903
- 35 Army Medical Department Report, 1898 (quoted from No 12)
- 36 Williams Journal of Tropical Medicine, June 1900
- 37 British Medical Journal, Vol I, 1904

### III.—Bacteriological.

During a small outbreak at Vienna in 1887, Weichselbaum (1) first identified the organism which is generally considered to be the ætiological factor in cerebro-spinal fever. Prior to his discovery other observers had noted, in cases of meningitis, various microbes, chiefly cocci, which they had found in the blood or in the meningeal exudate, most of their observations, being incomplete and having been made before bacteriological technique had become perfected, need not be referred to here, as their value is purely historical. In 1884 Marchiafava and Celli, (2) in two cases of meningitis, found cocci within the leucocytes of the exudate. In 1886, during the epidemic at Cologne, Leichtenstein (3) recorded that, in nearly every case he examined after death, he observed in smears from the purulent meningeal matter "micrococci which he likened to gonococci." Weichselbaum, in his original paper, however, not only defined the intracellular position of the organism, but also recorded its biological characteristics, such as its appearance on agar-agar, inability to grow at room temperatures, low vitality of artificial culture, inability of the cocci whether in smears from the exudate or in slides from cultures to retain Gram's stain, and its weak pathogenic properties. The microbe thus isolated Weichselbaum termed the "*Diplococcus intracellularis meningitidis*."

Weichselbaum's statements, coming as they did towards the end of a period of epidemic prevalence, were not confirmed for several years. Their import was noted, but it was considered, especially by the French and Italian schools, that Weichselbaum's microbe was only a variety of the

pneumococcus of Fraenkel and at the tenth Berlin Medical Congress of 1890, Foa (4) and other Italians declared this to be the case. This view has been widely held and has not yet been altogether abandoned, but Netter, (5) who prominently maintained this, has recently stated that he now considers the two microbes to be distinct organisms, he still holds the opinion that the pneumococcus is a prominent aetiological factor in epidemic cerebrospinal meningitis.

Jaeger (6) in 1895 was apparently the first to confirm Weichselbaum's observations. He alleged, however, that the microbe possessed other characteristics, *viz*, "capsule formation," "retention of Gram's stain in smears from cultures," and a tendency to grow into streptococcus form with a longitudinal line of division. Hoidheim and others support Jaeger as to the streptococcus-like forms, while Hunter and Nuthall (8) state that the diplococci obtained by them all exhibited capsule formation and did not always behave towards Gram's stain in the manner described originally by Weichselbaum. Their paper (8) contains several discrepancies in case VIII, on page 1527, the diplococcus obtained is said not to retain Gram's stain, whereas on the previous page in table I and on the same page in table II it is classed with the Gram retaining diplococcus which is considered by the authors to be identical with Still's diplococcus, a reference to Still's paper in the Journal of Pathology and Bacteriology, Volume V, 1898, page 151, shows that Still's organism did not retain Gram's stain nor did it exhibit a capsule.

The accuracy of Jaeger's work has been questioned by Weichselbaum and his colleagues and between the two schools, German and Austrian, a vituperative controversy, "die Meningokokken-polemik" was waged in the pages of the Centralblatt für Bakteriologie in March and April 1903 (9) on the subject of the biological characteristics of the meningococcus. In this Jaeger still maintains the position he took up in 1895, and further states that the organism is capable of desiccation and that infection always occurs through the nose. Weichselbaum and his colleagues deny the presence of a capsule, the power of retention of Gram's stain and the streptococcal forms and add that further proof is required of the property of desiccation and of constant nasal affection. The statements of the latter have received considerable support in the United States. Councilman, Malloy, and Wright (7) have completely confirmed Weichselbaum's observations and the opinion is held by all American writers that the meningococcus, a Gram-negative diplococcus, is the causal factor in epidemic cerebro-spinal meningitis or cerebro-spinal fever. In my experience limited as it is to about seven cases, the organisms which I have isolated, conform in every particular to the microbes

described by Weichselbaum and Councilman. It is to be hoped that the powerful commissions appointed in the United States and in Germany to study the present severe epidemic prevalence of the disease in their respective countries, will in the course of their work finally define the characters of the meningococcus.

*"The Diplococcus intracellularis meningitidis"*

*Synonym "The meningococcus"*

*Morphology*—In smears, made from the material obtained during life by lumbar puncture or from the meningeal exudations at an autopsy, this organism appears as a diplococcus, contained for the most part within the polymorphonuclear cells. One to eight or more diplococci may be thus seen and sometimes the nucleus appears so crowded with organisms that it is not easy to distinguish the nucleus. In almost every specimen examined some diplococci will be found to be extracellular, and occasionally a larger number will be observed to be outside than within the cells. Care, however, must be exercised during the preparation of the smear. If the fluid is too roughly spread over the slide, cells containing diplococci will be ruptured and their contents escape and appear to be free in the fluid. The diplococci are about the same size as the ordinary pyogenic cocci. Their shape varies to a small degree; they consist most frequently of two equally-sized hemispheres with their opposing surfaces flat, slightly concave or occasionally convex, but always separated by a distinct space. The elements are not always equal in size. This is more frequently seen in specimens made from artificial cultures. Neither in smears from exudates nor in those from cultures do the diplococci ever appear to be capsulated. In smears from a culture on blood-agar or other such suitable medium, the diplococci appear mostly isolated, but a few are grouped as tetrads. Very rarely and then always in old cultures are larger masses to be observed. Short chains of three or four diplococci are occasionally seen, but I have not met with the longer chains described by Jaeger. After four or five days' culture on any medium, the diplococci become distorted in shape, unequal in size, and they are less deeply stained.

The diplococci, whether in smears from exudates or from cultures, can be easily stained by any of the ordinary dyes. Beautiful preparations of the former are to be obtained by employing the Romanowsky method or Leishman's modification of it. Gram's stain is not retained but, as I have already said, there has been a considerable divergence of opinion on this point. I consider this to be due to a want of uniformity in the procedure of staining by this method. E. Neide has recently emphasized this in a paper of which I have only been able to see a short review.

(14) The following is the manner in which I have employed this characteristic reaction. Freshly prepared aniline-gentian violet is poured on the smear, already fixed by heat or by alcohol and ether, and is allowed to remain on for from a half to one minute. The stain is then poured off and the slide is then flooded with fresh Gram's solution, which is kept on for another minute. This in turn is poured away and absolute alcohol is carefully poured on the smear and allowed to run off until the washings are clear. The slide is then bathed rapidly in water, dried and examined. The diplococcus intracellularis, whether in an exudate or in a culture smear, is completely and rapidly decolorised while organisms such as the pneumococcus and the pyogenic cocci retain the violet colouration.

The organisms, which, in appearance, most closely resemble the meningococcus are, Fraenkel's pneumococcus and Neisser's gonococcus. Apart from biological differences, the common lanceolate shape of the former and its constant retention of Gram's stain are sufficiently distinctive. Morphologically it is difficult, however, to differentiate the gonococcus. It is also frequently intracellular and is a Gram-negative organism. The gonococcus is cultivated with greater difficulty and possesses other pathogenic properties than does the meningococcus.

*Biology Methods*—The meningococcus is not an easy organism to isolate and grow artificially. It is necessary to inseminate large quantities of material, whether cerebro-spinal fluid obtained during life or exudate procured after death, on a number of tubes and plates must be kept at a temperature near that of the body, viz.,  $37^{\circ}\text{C}$ , but even then several of them will fail to show any growth. Not infrequently and especially in cultures made after death, the presence of other microbes, which may or may not be accidental, renders the isolation of the meningococcus a still more difficult matter. From a capsule of purulent fluid obtained from the autopsy of a case of cerebro-spinal fever at Bhagalpur, the smears showed a few intracellular diplococci and many short bacilli. Cultures proved the latter to be bacillus pyocyaneus and plates and tubes were covered with pure growths of this organism. As recommended by Osler, I have found that the best method is to plate out about one cubic centimetric of the original fluid on alkaline five per cent glycine agar, after forty-eight hours' incubation at  $37^{\circ}\text{C}$  minute transparent, circular greyish-white colonies, rarely numerous and present in about three out of five plates, are to be seen. These, being proved by staining to be pure diplococcus growths, were immediately subcultured on "blood-agar," "agar," or "blood-serum," the first-named, in my experience, producing the best and most viable cultures.

*Conditions of growth.* Temperature—The optimum temperature

for this organism is about  $37.5^{\circ}\text{C}$ , its range of temperature between  $23^{\circ}$  and  $45^{\circ}\text{C}$ . At the room-temperature in Kasauli, which varies from  $10^{\circ}$  to  $12^{\circ}\text{C}$  in winter to  $23^{\circ}$  to  $26^{\circ}\text{C}$  in summer, no growths were obtained. This corresponds to the experience of other observers. It further constitutes another point of distinction between this organism and the pneumococcus, some strains of the latter growing well at  $18^{\circ}$  to  $20^{\circ}\text{C}$  and even at as low a temperature as  $14^{\circ}\text{C}$ .

The thermal death-point for this organism is about  $51^{\circ}\text{C}$ . This was ascertained as follows. Blood-bouillon growths incubated for three days, were placed in water heated to a temperature about  $5^{\circ}$  below that at which the first observations were to be made. The temperature of the water was then raised to the point desired and was maintained there for fifteen minutes, cultures on blood-agar being made at intervals of five minutes. The heat of the water was then raised another couple of degrees and the same procedure carried out. The agar cultures, thus obtained, were incubated along with controls at  $37^{\circ}\text{C}$  for forty-eight hours and the results noted. The whole experiment was repeated on several occasions with different strains and the above conclusion arrived at.

*Atmosphere* —The meningococcus is an obligatory *aërobie*. Attempts to grow it anaerobically proved negative.

*Cultivation media* —The reaction of the medium must be alkaline. If a trace of acid is present, no growth will be obtained.

The best media are blood-agar and blood-serum. To prepare the former, the following method has been employed with excellent results. The tip of the third or fourth finger of the left hand is thoroughly cleansed with soap and water and then with five per cent carbolic lotion. Alcohol and ether are successively poured over the finger, which is allowed to dry and is then pricked with a sterile needle. The blood, that exudes, is then sucked into a sterile pipette with a bulb on it (capacity about 5 c c). With the aid of an assistant, who opens the tubes, one or two drops of this blood are placed rapidly in succession on as many agar slopes as possible. The blood thus deposited is then spread over the surface of each slant with a sterile bent glass rod. The tubes are then placed in the incubator for twenty-four hours so that accidental contaminations may be eliminated. It may be observed that such contaminations are exceedingly rare. More luxuriant growths and a greater viability have been exhibited by the meningococcus on this blood-agar medium than on any other. After incubation for twenty-four hours, a good culture of recent origin appears as a number of small circular raised almost transparent greyish-white colonies with margins,

even at first, becoming somewhat crenated later. The colonies are so viscous that they can be separately lifted off the surface of the medium and transferred to another tube. After three or four days they form rosette-shaped and marked patches, somewhat raised, and more opaque at the centre than at the periphery, where the growth is transparent. A streak culture exhibits a raised viscid greyish-white line with margins which soon become irregular. If the culture has been well spread over an agar slant, an appearance like "white paint," such as Stall has described, is to be seen.

On blood-serum of the horse, inspissated in the usual manner, good but rather pale growths were obtained. Councilman and his colleagues have stated that Mallory's modification of Loeffler's blood-serum mixture was found by them to give the best results. Of this medium I have no experience nor did I consider its preparation necessary, securing as I did such excellent growths by the blood-agar procedure, which possesses the merit of simplicity. On ordinary agar, compared with either of the above media, a feeble, unequal growth obtains. Alkaline five per cent glycerine agar is better, with blood added, it is the best of all. No growth was obtained on glucose or litmus agar. On blood-glucose-agar a slight growth appeared.

In ordinary bouillon a fair growth in the form of a stringy, viscid mass at the bottom occurred. A slight general haziness of the fluid preceded this. If a drop or two of sterile blood were added to the bouillon before inoculation, a good growth ensued, after six or seven days an appreciable amount of deposit was visible at the bottom of the tube, the supernatant fluid being quite clear.

On potato no growth was obtained.

In milk the diplococcus flourished moderately well, but neither coagulation nor acid formation resulted.

On gelatin all the cultures failed.

*Vitality*—The vitality of this organism even on the best medium and at the optimum temperature is not remarkable. To maintain a particular strain it is necessary at first to make more than one subculture daily. Later as the strain becomes older its viability increases and subcultures every second, third or even fourth day are only essential. A strain obtained direct from the body required, after three months' continuous subculture to be planted out every third day. An occasional culture for some undetermined reason exhibited a much greater vitality than this. With a five months' old culture the maximum vitality on blood-agar was fifteen days, in blood-bouillon eighteen days. In all cases the cultures were kept continuously in the incubator at 37.5° C.

*Resistance to acids, etc* —Further evidence of the feeble viability of this microbe is afforded by the exceedingly weak resistance offered to acids, alkalies, and disinfectants. Councilman found that dilutions of formaldehyde gas up to 1-225,000 destroyed smears of this organism on paper after an exposure of four to seven hours. Bouillon containing carbonic acid in the dilution of 1-800 also showed no growth. I have repeated the latter experiment, obtaining an identically similar result. No growth was obtained in blood-bouillon containing commercial formalin in dilutions of from 1-100 to 1-1000.

*Resistance to desiccation.*—In view of the statements made that the organism is capable of desiccation and of continuing a saprophytic existence in dust, the experiments of Germano were repeated on several occasions with three different strains. The results were practically negative and in no way did they conform to those obtained by Germano. Germano's method as described by Nuttall (11) was followed as closely as possible. Rich cultures on blood-agar after forty-eight hours' growth were emulsified with small quantities of sterile bouillon. The emulsions were then dried in sterile petri dishes over  $H_2SO_4$ . When dry the material was broken up with a sterile rod and mixed in quantities of about 5 grammes of dried emulsion with 4.6 grammes of either dust from a room, garden-earth, or mixtures containing sand or lime. These are placed in sterile test-tubes which were kept in a drawer in the laboratory and were either untouched or were moistened every third day with sterile water. Other such mixtures in similar quantities were kept in previously sterilised capsules over  $H_2SO_4$ .

The following were the results obtained —Series No 1. In this a growth obtained from Major Roberts, I M S, Indore, was employed, its pathogenicity, on arrival at Kasauli, was negative, it was tested when it was three months old. Three tubes of each mixture, under each condition of desiccation, were kept for ten days. On the eleventh day from one of the three tubes containing a mixture with dust of the room, kept untouched in the laboratory drawer, a diplococcus was recovered, simulating in its growth and non-retention of Gram's stain, the original microbe. This was done by plating a loopful of the mixture on alkaline five per cent glycerine agar. Five days later this organism had died out and subsequent cultures from this or from any other of the tubes in this series were failures as regards recovery of the diplococcus. The entire experiment was repeated at a later date with a completely negative result.

Series No 2. A growth obtained on February 1st, 1904, from arthritic fluid sent by Lieutenant Nutt, I M S., was employed in this series. A recent subculture pathogenic to rabbits by subdural inoculation



was treated as above and examined at intervals of ten days. No diplococci were ever recovered

Series No. 3. A culture obtained from a case in Lahore in May 1904 was employed, it was pathogenic to rabbits by subdural inoculation to a slight degree. This was similarly treated and examined at intervals of ten days without result

*Pathogenic effects on animals.*—It is one of the features of this microbe that it is practically non-pathogenic to animals of the types commonly employed for experimental purposes in laboratories. This, in itself, constitutes a considerable impediment to all research connected with the organism. The records of animal inoculations of all observers exhibit, more or less, a succession of failures. Councilman, on one occasion, succeeded by intraspinal inoculation in inducing meningitis in a goat, but a sheep inoculated at the same time in a similar manner survived. Heubner has also succeeded thus in inoculating goats. Other experimenters have been equally unsuccessful. Councilman infected six guinea-pigs out of a large number by intraperitoneal or intrapleural injection. All his intraspinal experiments on animals, other than the goat referred to, were failures.

The following are the results I have obtained in my animal experiments. Neither mice nor guinea-pigs could be employed, the former not being obtainable while the latter were not plentiful enough for a large series of experiments considering the other requirements of the Institute. A few young rats were obtained on one occasion, but the two subcutaneous and the two intraperitoneal inoculations done on these were all unsuccessful.

On goats I have performed four experiments.

I. *Goat No 1* received subdurally, under ether anaesthesia, one cubic centimetre of an emulsion made by adding two cubic centimetres of sterile broth to a twentyfour hours' culture of the meningococcus on blood-agar. The strain employed was that received from Major Roberts at Indore, its age was considerable. The goat was alive and well three months after the operation and never showed any signs of infection.

II. *Goat No 2* was inoculated subcutaneously with the remaining cubic centimetre of the above emulsion on the inner side of the right thigh. Local reaction followed, which disappeared in a couple of days time. A month later the goat was alive and well.

III. *Goat No 3* received intraspinally two cubic centimetres of an emulsion of a three days' old culture of the meningococcus on blood-agar. (Lahore case II subcultivated for three weeks.) This goat was ill for a couple of days, but recovered perfectly and was alive and well some months later.

IV. *Goat No 4* received intraspinaly two cubic centimetres of a twenty-four hours' culture on blood-agar (Lahore case II five weeks old) In this instance all the fluid entered the canal, whereas in the previous one it is certain that most of it did not. In the above case the operation was followed by considerable local œdema. In this the goat exhibited slight paresis of both hind legs on the following day, but there was no local œdema. This goat also recovered perfectly.

With regard to these experiments all of them and especially Nos I and II were performed with growths which had been artificially subcultivated for too long a period. In the case of experiments III and IV, the earlier subdural inoculations on rabbits had produced more definite results, as these showed that the strain of microbe recovered possessed at first a slight degree of pathogenicity, further experimentation on goats was not considered necessary. The later experiments were done with a view to induce meningitis in order, if possible, to obtain a microbe with an exalted virulence. They were, however, complete failures.

On rabbits a large number of experiments have been performed the general results attained have been as follows. Subcutaneous and intraperitoneal inoculations have not succeeded in any instance, for these both the fluid obtained by lumbar puncture and pure growths recent and old from the same source have been employed. Large amounts have been given by the former method a growth, third remove from the body, thickly smeared over the surface of an agar tube, has been emulsified with 4 c c of sterile bouillon and the whole inoculated subcutaneously into a rabbit without producing the slightest result. With subdural inoculations more definite results were obtained.

The following are some of the experiments performed on rabbits —

Series I. Fluid obtained from Lieutenant Nutt, Derà Ghazi Khan, February 1904.

*Rabbit No 6* received 2 c c of original fluid, subdurally, under an anæsthetic. (All the subdural operations were performed under complete ether anæsthesia.) It recovered from the operation and remained well for six days: it then began to refuse its food, emaciate, etc, died on the fourteenth day. After death an examination revealed slight congestion of the pial vessels. Increase of the cerebro-spinal fluid proved free of organisms by culture and microscopically other organs healthy.

*Rabbit No 7* received on same date as No 6 .2 c c of the original fluid intraperitoneally was placed in same cage: never suffered from the operation and continued healthy for more than three months.

*Rabbit No 8* received subdurally 2 c c of an emulsion of a blood agar culture made with sterile bouillon. The culture was a first remove

from the body and had been incubated for forty-eight hours. It died sixteen hours after the operation and was examined at once. On opening the skull and vertebral column a fine leptomeningitis of the brain and cord was displayed, with minute flakes of purulent lymph here and there. Smears showed typical diplococci, intracellular as well as extracellular, cultures on blood-agar were most successful, ten to twenty colonies appearing on each tube. Cultures from heart, spleen, lungs, and liver all failed. The culture employed in this experiment was the same as that used in the second series of desiccation experiments.

*Rabbit No 10* received subcutaneously .3 c.c. of an emulsion of a blood-agar culture, then removed from the body, incubated for twenty-four hours. No symptoms until fourteenth day, when it was attacked with acute enteritis and died thirty hours later; at the autopsy slight peritonitis was found, smears and cultures from this exudate showed numerous organisms of the *B. coli* type. Meningeal and blood cultures remained sterile.

*Rabbit No. 11* received subdurally .2 c.c. of the same emulsion as Rabbit 10. It exhibited typical meningitis on the following day, retraction of the head being prominent. It died sixty hours after operation at midnight. Was placed in ice and examined ten hours later. Pathological appearance was similar to those of No. 8, a few diplococci were seen in the smears, only one culture was successful.

*Rabbit No 13* received subdurally 2 c.c. of an emulsion made from a twenty-four hours' culture when the strain was nearly seven weeks old. The animal survived, never exhibiting any symptoms.

The comparative success of this series of experiments is due to the fact that they were performed with recent cultures. The original fluid arrived at Kasauli in the cold weather within twenty-four hours of its removal from the body.

Series 2. Material obtained by lumbar puncture from cases in the Lahore Central Jail. (These cases are detailed in the appendix.)

*Rabbit No 21* received subcutaneously 2.5 c.c. of the original fluid (case II) obtained by lumbar puncture seven days previously. The rabbit remained well after the operations for 32 days, it was then found dead in its cage, no cause could be assigned for death.

*Rabbit No 22* received subdurally 2 c.c. of the same fluid as used in No 21. It recovered completely from the operation, remained well for four weeks, then began to refuse its food, emaciate, etc. It died on the forty-eighth day, the pathological examination was negative. The emaciation in this and the other cases was remarkable.

*Rabbit No 23* operated on the same day as No 22 with a similar

amount of the original fluid. It never exhibited any symptoms and was alive and well three months afterwards.

*Rabbit No 24* received subdually 2 c.c. of original fluid (case IV). This rabbit also survived and remained in good health.

*Rabbit No 27* received 3 c.c. of the original fluid (case II), incubated for ten days. It was ill for two days, recovered, but began to refuse its food on the eighth day. It died on the seventeenth day very emaciated: on examination no signs of meningitis nor of lesions of any organ were found. All cultures were negative.

*Rabbit No 29* received subdually 3 c.c. of original fluid (case IV), incubated for ten days. This animal remained well for a time, then progressively emaciated like the others and died on the thirty-second day.

*Rabbit No 30* received subdually 2 c.c. of an emulsion of a forty-eight hours' culture on blood-agar (second remove from case II). It died on the twenty-seventh day and its illness, death, and pathological appearances were similar to the others.

*Rabbit No. 31* was treated in a like manner to No 30 with a culture from case IV. It died in similar fashion on the thirty-first day.

The interesting feature of this series is that most of the subdual experiments corroborate the statements made by Osler, who remarked that animals inoculated subdually died from the fourteenth to the forty-second day, that in no case were gross lesions found, nor was the meningococcus recovered, that the animals were greatly emaciated.

*The experiments of Busquet*—Netter (5) has written the following interesting note on certain experiments of Busquet:—

“Following Modin, Weigert, and Stiumpel, I have held that in meningitis the pathogenic agent penetrates into the meninges by the rather easy pathways of communication between the nasal fossæ and the base of the cranium (cribriform plate of the Ethmoid). Busquet maintains that he has decisively proved the truth of this view experimentally. In three series of experiments he has succeeded in infecting guinea pigs and rabbits by introducing into the usual fossæ a small probe carrying nasal mucus taken from persons suffering from the disease or from convalescents or cerebro-spinal fluid obtained at an autopsy. In a space of time varying from one to three days, the animals presented morbid symptoms, fever, general fatigue, prostration, torpor, rapid and marked emaciation and diarrhœa. One of them on the thirty-fifth day was attacked with paralysis of the left leg. Five of the animals died. The cephalorachidian fluid was found to be a little above normal in amount and usually clear. The meninges at the base of the brain were found to be congested. The meningococcus was isolated from the cephalo-rachidian

fluid and the pleura." I was unable to repeat Busquet's experiments with similar material, but with the fluid obtained from the Dera Ghazi Khan case I attempted to infect the nasal fossæ of two rabbits. Both of them survived as did three others, in whom fluid from the cases at Lahore was employed.

*Microbic association*—Considerable stress has been laid by most observers on the presence of other organisms along with the meningococcus in cases of cerebro-spinal fever. In many instances these must have been contaminating factors, they are seldom recorded as having been observed in the smears and were present in cultures only. Lumbar puncture is not an operation which can always be carried out so perfectly as to secure that the fluid obtained will not be contaminated. In six punctures I have only obtained the meningococcus once in pure culture. This was the first puncture of case No. II at Lahore. The puncture of case I on the same date was sterile while that of case IV showed colonies of staphylococcus citreus and albus in addition to the meningococcus. The smears in this latter case showed only a few intracellular diplococci. A chromogenic diplococcus, which resembles Balthazard's diplococcus meningitidis aureus was also isolated from the fluid of case IV. The cultures from the second puncture of case II, performed after an interval of twenty-three days, likewise exhibited colonies of staphylococcus citreus and albus as well as the meningococcus, while those from case IV on the same occasion were almost pure cultures of the chromogenic diplococcus recovered on the first occasion. The smears now showed a few extracellular diplococci. The meningococcus was also present. In a case punctured at Fyzabad staphylococcus citreus and an undetermined bacillus were present in the cultures in addition to the meningococcus. I have not met with cases in which the pneumococcus, streptococcus pyogenes or the tubercle bacillus were present in association with the meningococcus.

### Other organisms which have been considered as ætiological factors in Cerebro-Spinal Meningitis.

#### 1. *Pneumococcus, Diplococcus, Pneumoniæ* (Frankel)

Lamb, as previously mentioned, isolated this organism from a case at Poona and in sections of the spinal cord, which had been kept embedded in paraffin for two years, I stained the pneumococcus in the exudate by Gram's method. The lung from the same case exhibited a pneumonic condition simply crowded with pneumococci.

Dunn met with two or three cases of pneumococcic meningitis at Calcutta, during the cold weather, 1903-1904, from which he isolated

the pneumococcus in pure culture and sent me cultures. With one of these, for comparative purposes, I performed the following experiment on a rabbit.

*Rabbit No. 12* received subdually '2 c.c. of an emulsion of a forty-eight hours' culture on blood-agar made with one cubic centimetre of sterile bouillon. The rabbit died twenty hours after the operation. At the autopsy, three hours after death, the brain and cord were found to be bathed in an hæmorrhagic exudate. From the latter smears revealed numerous pneumococci and good pure growths of the same organism were also obtained as they were from the heart's blood. The brain and cord were preserved in formalin, the other organs including the lungs were apparently healthy.

After hardening and cutting sections in paraffin, those of the brain, stained by gram and eosin, showed that the hæmorrhagic exudate in the pia-mater was crowded with pneumococci, there was also a large circumscribed hæmorrhage, full of pneumococci, in the substance of the right cerebral hemisphere above the hippocampus major. The cord exhibited similar appearances except that in its substance were three small hæmorrhages—one in the right anterolateral tract, one in the right anterior cornua and a large one in the left column of Burdach. Sections of the lung were normal. The operation induced an acute pneumococcal meningitis with, in addition, a general septicæmia as evidenced by the presence of the organism in the blood. The experiment emphasises the pathogenic differences between this and Weichselbaum's microbe, the greater pathogenicity of the former being very characteristic.

*Morphology and biology*—The pneumococcus is a capsulated diplococcus with oval or lance-head shaped elements, rarely circular and never semilunar, found in the rusty expectoration of acute lobar pneumonia, in the exudate of the affected portions of the lung in the same disease and in the blood, etc., of inoculated animals. In cultures the cocci present a similar appearance, but capsulation is less evident. Short chains of 6—8 cocci are to be obtained from bouillon cultures. The organism stains well by all ordinary strains and it retains the stain by Gram's method. Its optimum temperature of growth is that of the body, but its range is wider than that of the meningococcus. It is a facultative ærobe, growing best on alkaline media, of which blood-agar and blood-serum are the best. Its vitality on any media is moderate. The early colonies on blood-agar or other media simulate in appearance those of the meningococcus, but they are brighter in aspect and are without the greyish tinge of colouration. Later, the pneumococcus colonies become opaque and of a buff colour. The pneumococcus is further distinguished by its ability

to grow on gelatin and by its coagulating milk and forming acid therein

## 2 *The Streptococcus of Bonome*

Steinberg states (13) that Bonome in 1890 obtained this encapsulated streptococcus from cerebro-spinal exudates and hemorrhagic extravasations in the lungs in cases of epidemic cerebro spinal meningitis. Bonome alleged that it was distinguished from the pneumococcus by not growing on blood-serum, by living for five or six generations only on artificial media and by its ball-shaped colonies. Pathogenically it simulated the pneumococcus. As far as I have been able to ascertain, this organism has been recorded only from France. It is there considered to be a variety of the pneumococcus and indeed Netter states that he was able to transform the "Bonome" microbe he obtained in 1898 into a pure pneumococcus by a series of inoculations and cultivations.

## 3 *Diplococcus Meningitidis Aureus.*

Balthazard (12) has described a case of cerebro-spinal meningitis, from which he recovered both of the fluid obtained by lumbar puncture during life and in the exudate at autopsy, a capsulated diplococcus characterised by a chromogenic growth on all media. As he isolated it in pure culture, he considered it to be the ætiological factor in this particular case. He found the cloudy liquid obtained by puncture or *post-mortem* to contain numerous leucocytes chiefly neutrophile polymorphs not degenerated. In some of these capsulated diplococci were present but numbers were few. The diplococci retain Gram's stain strongly. Cultures were made on serum, agar and in bouillon.

"On serum and agar after twenty-four hours colonies round thick and projecting of a deep chrome yellow centre opaque, the periphery refracting. Staining with aniline dyes one finds outside the masses of organisms, isolated encapsulated diplococci. They appear like round grains placed together very often flattened at the point of contact, at times lanceolate, very often one part is larger than the other. Stains by Gram."

"In bouillon after twenty-four hours a general cloudiness, examined microscopically shows remarkable capsulated diplococci, also short chains of four to six capsulated segments. Later a deposit is formed, but culture becomes cloudy on shaking. Microscopically there are present long streptococcal chains composed of diplococci separated, perpendicularly to the axis of the chain. These characters become still further exaggerated after 15—20 days. Milk is coagulated and rendered acid in four days. On potato yellow characteristic colonies are obtained on gelatine (18-22° C), growth of yellow colonies slowly obtained. Gelatine

liquefied. The organism is pathogenic for mice by subcutaneous, intraperitoneal, and intrapleural injection, but it is feebly pathogenic for rabbits or guinea-pigs. The organisms possessed great vitality, were still alive at the end of five weeks and retained their biological characters."

From one of my Lahore cases I obtained on both occasions an organism which in its cultural and morphological characteristics corresponds to the above. I had done this before I had seen Balthazard's paper and as I was not inclined to assign any importance to the organism, I only made a few notes of its main characters.

On reading Balthazard's account I was struck with the resemblance to the organism I had obtained and which I had already labelled "*Diplococcus B*." After further studying the latter, I now feel certain that it is identical with the *diplococcus meningitidis aureus* of Balthazard. In smears from cultures on solid media the capsular appearance has not always been made out, but the organism was already fairly old before I began to study it carefully. In bouillon growths capsulation is always present and the streptococcal forms are very striking. On the various media appearances identical with those described by Balthazard have been obtained. I have also cultivated the organism on blood-agar, glycerine-agar, and glucose-agar. On the latter it grows luxuriantly. The few inoculations I have performed on rats, rabbits, and guinea-pigs have not been productive of any result. The relation which this organism bears to that of Weichselbaum and to the disease in either of its forms can only be made out by its further recovery in a larger number of instances.

### References.

- 1 Weichselbaum. Fortschritt der Medicin 1887. Band V, pp 18-19
- 2 Marchesani and Celli Gazz. d. osped., 1881 quoted from Weichselbaum (reference 9)
- 3 Leichtenstern. Deutsche Medicinische Wochenschrift, 1885
- 4 Pon. Quoted from reference No 8
- 5 Netter. Twentieth Century Medicine, Volume XXI, 1902.
- 6 Jaeger. Die Cerebrospinal Meningitis als Heereserkrankung. Berlin 1901
- 7 Councilman, Mallory, and Wright. Report to the State Board of Health. Boston 1898
8. Hunter and Nuthall. Lancet, June 1, 1901
- 9 (a) Albrecht and Ghon. Centr. f. Bakter. 1 abt. orig. Bd XXXIII, pp 496-510  
(b) Weichselbaum, Centr. f. Bakter. 1 abt. orig. Bd XXXIII, pp 510 to 531.  
(g) Jaeger Centr. f. Bakter. 1 abt. orig. Bd. XXXIII, No. 9, pp 681-682.
- 10 Osler. British Medical Journal, June 24, 1899
11. Buchanan. Journal of Hygiene, Vol. 1, 1901.



12 Balthazard. *Journal de physiologie et pathologie générale*, January 1903

13 Sternberg, *Bacteriology*, 1896.

14 E Neide *Centralblatt für Bakteriologie I originale* Band XXXV, 16 Jan 1901, pp 518 521, quoted in "*Bulletin de l'Institut Pasteur*, No 8, April 30, 1901

#### IV.—Epidemiological and General.

In the accepted sense of the word, the disease can hardly claim to be termed "epidemic" Its classification with influenza as "pandemic" has been suggested by Stille This is better, perhaps, but it must be remembered that the ravages of influenza are much more widespread and approach a true epidemic form more often than do those of cerebro-spinal fever Remarkably few persons are attacked by the latter and no specific disorder proceeds in such an irregular manner The cases follow each other at variable intervals of time, at places widely distant one from another and a connection between successive attacks has seldom been traced. But, occasionally, what are known as "house-epidemics" have been recorded, in these several members of a household have become affected by the disease, very rarely simultaneously and generally one following the other. Nearly every writer who has observed the disease among a free community, records one or more extraordinary instances of this nature The most notable of all of these is, perhaps, that of Osler's, who relates how five members of a family became successively afflicted, the disease being then only sporadically prevalent in the town The small outbreak of four cases in the same barrack of the Lahore Central Jail in April 1904, which I have already described, is the only instance of this kind which has been observed in India

*Contagiousness of the disease.*—The general trend of opinion is that the disease is not, as a rule, contagious, but, under certain conditions the precise nature of which we are unaware, contagion would appear to have been present as is evidenced by the numerous house-epidemics to which I have just alluded An excellent summary of the observations on this point is contained in Councilman's monograph Leichtenstein is quoted by the authors of that paper as having studied the contagiousness of the disease at Cologne in 1885 of one hundred and eighty attacks, which he observed, no less than one hundred and fifty, as far as could be ascertained, came one from each separate house The Indian data are all in favour of the non-contagiousness of the disease, but these, it must be remembered, are drawn mainly from jails With the exception of Williamson and Orr, no one would appear to have observed the disease, when it prevailed among a free population and there are no records, except the solitary jail one above-noted, of such house-epidemics as have been recorded from America and Germany The manner in which the disease

spreads in a community is unknown, it is highly probable that it is air-borne and in this connection dust may play an important part as an associate factor.

*Relation of sporadic cases.*—Comparatively few of the numerous sporadic instances of the disease, which have been recorded, have been bacteriologically studied. Their identity with the true epidemic form remains to a certain degree questionable, but, from the cases, within recent years, in which the diplococcus of Weichselbaum has been shown to be the causative factor, we may infer that the bulk of the previously-described sporadic attacks are similar in nature to the epidemic ones. As with many other diseases, an epidemic is anticipated by a number of isolated cases. It is characteristic of this disease that these may occur at long intervals of time and indeed may bridge over a period of twenty years between successive outbreaks. The history of the disease in America is, as Osler has pointed out, very interesting in this relation. In the nineteenth century there were four marked periods of epidemic prevalence, in the intervals between which sporadic attacks were observed with great regularity. In Upper India sporadic attacks are observed in many of the large stations every cold weather. In Calcutta and Lahore two or three patients suffering from cerebro-spinal fever are admitted during the winter or spring months into the large hospitals. Major Roberts records a similar experience from Indore. In 1902-1903 he observed four such cases and from one of these he sent me a pure culture of the diplococcus intracellularis, which he had obtained by lumbar puncture.

*Relation of pneumonia to cerebro-spinal meningitis.*—The question of the relation of pneumonia and pneumococcal conditions to cerebro-spinal fever is an interesting one. It was formerly considered that this relation was very close; for, as Osler has pointed out, the two diseases have several features in common. Both exhibit sporadic attacks in the intervals of their epidemic prevalence, when they do occur epidemically, they are more prone to do so in institutions such as jails and barracks, they further simulate each other in their abrupt onset, in the presence of herpes labialis and a leucocytosis, and in the identical characters of their fibrino-purulent exudates. Pneumonia may complicate cerebro-spinal fever, but this occurs more rarely than was, at one time, supposed. In only two of Councilman's one hundred and eleven cases was croupous pneumonia present, but several others showed foci of broncho-pneumonia from which the pneumococcus was recovered. In India, among Buchanan's cases only three exhibited any demonstrable lung condition. Indeed in India a pneumonic complication has been

proved to be quite exceptional and the coincident prevalence of pneumonia has only been once remarked in this country, in contra-distinction to the observations made in other places in which the diseases prevailed simultaneously. Leichtenstein has been quoted by Osler and others as very aptly indicating the points of difference between the two diseases. He says "Pneumonia is a disease spread over the entire earth and appears at all times, there being no land immune from it. Epidemic meningitis is very rare, in many countries it is still unknown. Croupous pneumonia attacks every age, the predisposition increasing with advancing age. Epidemic meningitis is a disease which affects children and young people, beyond thirty-five there is a slight disposition to it. Croupous pneumonia has a typical course and a crisis. Epidemic meningitis has no crisis. The complications of the two diseases are different."

The idea of a close relationship between these two diseases arose from the fact that the French school headed by Netter believed for a long time that the meningococcus was only a degenerate form of pneumococcus. But Netter has recently abandoned this view and in his latest writing on the subject he says "We frankly acknowledge that up to the present time no facts have appeared to justify such a supposition and that there is every reason to believe that the pneumococcus and Weichselbaum's organism are different microbes." Netter, however, still holds that the diplococcus intracellularis is not the sole ætiological factor in epidemic meningitis. He adduces evidence to show that a number of epidemics in France, Northern Italy, and Algiers were caused by the pneumococcus alone, while in others he has simultaneously observed cases, some due to the meningococcus, others to the pneumococcus or one of its varieties. In other countries pneumococcic meningitis has been much more rarely encountered. In the records I have obtained from India there are two distinct cases of pneumococcic meningitis both of which are detailed in the Appendix.

*The course of the disease as it is seen in Indian jails* — When the disease becomes epidemic in a jail, it runs a course somewhat in this manner. The first case is followed by another after an interval of some ten to twenty days. Five or six days may then elapse before the third attack takes place and then at gradually shorter intervals cases occur in different parts of the jail and frequently in men unassociated either at their work or otherwise. A period of maximal intensity is soon reached during which there may be as many as sixteen or eighteen attacks within ten days. After this the disease shows signs of abatement. The cases become fewer, the intervals between their incidence lengthen

out and the outbreak terminates in a similar manner to that in which it commenced. In some epidemics no maximal period is evident; in the fourth outbreak at Bhagalpur and in the one at Rupon the attacks succeeded each other at intervals of two to five days throughout. Considering the number of persons in a central jail who are exposed to infection, it is remarkable that so few of them should be attacked. An outbreak of this disease is constituted by about thirty or forty attacks among a population of upwards of two thousand men.

*Manner of infection of jails*—The manner of infection of jails has not been satisfactorily worked out. In some instances the disease was imported from the surrounding free population or from a district in which it prevailed. This was undoubtedly the case in the outbreaks at the jails at Delhi and Hissar in 1902. In the epidemic at the Raipur Central Jail in 1899, although the disease was not reported to exist in the neighbourhood, the first case occurred in an under-trial prisoner who had been only six days within the jail precincts. The presumption is that this man brought the disease into the jail. It must be remembered that the absence of any records from a particular locality by no means negatives the presence of such a disease as this even in its epidemic form. It is always mildly epidemic and cases occurring without obvious association at irregular intervals may be easily overlooked and returned by the village authorities under the generic head of "fevers." But that the disease does exist and is spread over a very wide areas in India in a sporadic form, is evident, not only from the fact that cases have occasionally formed the subjects of medico-legal inquiry, but isolated attacks are constantly being heard of from different parts of Northern India.

Whatever the manner of primary infection, it would appear from most of the Indian prison records that when the disease gains a foothold in a jail it remains there for a considerable time, periodically assuming such proportions as to warrant its being considered epidemic. The historical data of the jails at Shikarpur, Ahim, Bhagalpur, and Allahabad, all, by the way, very widely separated, abundantly prove this. But in all except Bhagalpur, we are compelled to admit the possibility of successive re-infection of the jails from without, for the disease has been definitely declared to exist among the free populations from which the bulk of the convicts are drawn.

*Prophylaxis with regard to jails, etc*—The measures necessary to prevent the entrance of cerebro-spinal fever into jails must be, in the present state of our knowledge of that disease, similar to those adopted with regard to other infectious disorders. Every prisoner admitted to an Indian jail has his own clothes taken from him, disinfected and placed

in a special store until his release; he is then bathed and given a suit of prison clothing and he is finally placed in a special segregation cell, where he spends ten days before he is allowed to join the general body of convicts. In addition to these precautions, the notification to jail superintendents and to regimental medical officers of the prevalence of cerebro-spinal fever in particular areas is necessary: and, as a corollary, the period of segregation imposed on new arrivals should be extended to twenty-one days. Although we possess as yet no record of such very mild attacks, still it is probable on the analogy of other diseases that cases, whose symptoms may not be more than a mild coryza with some pain and stiffness of the neck, may occur during periods of epidemic prevalence. Jail superintendents and medical officers might look out for these, as, should they exist, the importance of their recognition cannot be denied.

A case of the disease having occurred in a jail, it becomes incumbent on the officials in charge to take vigorous measures to prevent the spread of the disorder and to eradicate, as far as possible, the infection. These measures may be classified thus:—(1) the early and accurate diagnosis of the disease, (2) the removal of the patients to a separate cell or ward of the hospital, (3) the strict isolation of all the patients "contacts" for twenty-one days, and (4) the evacuation of the barrack room in which the cases occurred for a similar period, during which cleansing measures are to be enforced. The diagnosis, clinically, of a fulminant or an acute case of cerebro-spinal meningitis is not difficult, but, as not infrequently happens, the first case may be of a less distinct type and, while the patient is alive, his condition can only be accurately determined by recourse to lumbar puncture together with a bacteriological examination of the fluid obtained by that procedure. The bacteriological examination may be thus carried out, if the medical officer possesses the requisite apparatus, he may proceed at once to make cultures on blood-agar or glycine-agar, being careful to employ large amounts of the cerebro-spinal exudate. With all precautions small quantities of the exudate should at the same time be sealed up in glass bulbs for transmission to the nearest laboratory for confirmatory diagnosis: a number of smears should be made on slides stained by the methods of Romanowsky and Gram and examined for the characteristic diplococci. Some of the unstained smears together with a short clinical and pathological note of the case should invariably accompany the bulbs of material sent to a laboratory. It need hardly be added that these should always be despatched by the most rapid route. If the medical officer is without the means to verify his diagnosis, the despatch of morbid material becomes imperative and

should be carried out in every case as far as possible. At an autopsy a similar procedure is required and in addition small portions of the different parts of the cord, cerebrum, cerebellum, basal ganglia, cranial nerves, and ganglia with the pia-arachnoid membranes attached should be placed in five per cent formalin solution and transmitted for pathological investigation. As these tissues are delicate, it is better to wrap each portion in a thin layer of cotton-wool prior to placing it in the preservative. A portion of the lungs should always be added and, of course, any other pathological tissue found. The presence of cerebro-spinal fever having been thus established, the medical officer of the infected jail has then to carry out the isolation of the patients and their contacts, and the disinfection of barracks, etc., by the best means at his command. It is not necessary to detail these here, but it may be mentioned that the employment of tents for the former purpose in cold weather ought not to be forgotten. Should these measures fail to arrest the progress of the disease or should the jail become severely re-infected as was the case at Munger Bazar, the advisability of evacuating the entire institution for a variable period must be considered and, if deemed necessary, carried out.

*Prophylactic measures among the general populace.*—Considering how scanty, comparatively speaking, our knowledge of the disease is, these measures must proceed on the broad lines laid down for the treatment of similar epidemic disorders, viz, isolation of the sick, evacuation and disinfection of houses, and the removal of all gross sanitary defects. No prophylactic nor curative serum has been prepared as yet for the disease. I attempted to prepare serum from goats: as far as laboratory experimentation went, it seemed to be satisfactory, but I had no other opportunity of testing its efficacy. The lack of pathogenicity, which the meningococcus exhibits, greatly deters research in this direction.

*The conclusions which may be drawn from this study of the disease are these —*

- (1) Epidemic cerebro-spinal meningitis or cerebro-spinal fever in both its epidemic and its sporadic forms, is a well-known disease in India: the records of the disease show that it is clinically, bacteriologically, and epidemiologically identical with the malady as it has been observed in other countries.
- (2) In India it has been an ailment which has most frequently attacked prisoners in jails, in some of these institutions the disease has continued to prevail irregularly for prolonged periods. No explanation of this is at present possible. A

complete local bacteriological and epidemiological study of a severe outbreak, such as have occurred in past years at the jails of Bhagalpur and Mung Rasul, might be productive of useful data in this connection

Finally I must express my gratitude to many officers of my own service and of the Royal Army Medical Corps for assistance at various times. the names of most of these occur in the text, but I would specially mention Lieutenant Colonel D Semple, R A M C., Director of the Pasteur Institute, under whose guidance the above study was carried out, and Lieutenant Colonel J T W Leslie, I M S, Sanitary Commissioner to the Government of India, for much useful advice and help in the preparation of this monograph

C J ROBERTSON-MILNE, M B, I M S

## Appendix.

(a) Cases of Cerebro-Spinal Meningitis due to the meningococcus

1 Case at Dara Ghazi Khan reported by Lieut H R Nutt, I.M.S.

Basant Singh, sepoy aged 22 22nd Punjab

Name Basant Singh										Age 22										Disease Cerebro Spinal Meningitis										Result Death					
Date	8	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7						
Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29						
Time	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME					
Temperature (Fahrenheit)																																			
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97																																			
Pulse M																																			
Resp M																																			
Bowels E																																			
Urine																																			

Attacked on 7th February 1904 with fever and general malaise. Complained of great pain all over body and especially over left chest

Feb 9—Admitted into hospital, the above condition having continued. Pneumonic patch in left axilla. Pain in back of neck and head—slight rigidity—great pain on moving head laterally. No nasal discharge. General cutaneous hyperaesthesia especially marked over spine.

Feb 10—Small pneumonic patch right base.

Feb 11—Increased cervical rigidity and marked frontal headache. Erythema over chest. Effusion of fluid in right knee-joint.

Feb 12—Herpes tongue and mouth. Effusion increased in right knee and present also in left.

Feb 14—Patch of herpes over sacrum.

Feb 15—Slight deafness. Headache less, but cervical pain and rigidity still marked. Erythema has extended.

Feb 19—Effusion right knee still persists. Joint tense. Aspirated and a small quantity of purulent fluid removed and sealed up in a sterile tube and sent to Kasauli.

Feb 22—Headache and cervical rigidity still persists. Three ptechieal streaks on inner side of right knee joint, the opposite side to the puncture.

Feb 24—Patient continues to be very ill and is emaciating very rapidly. Slight facial paresis. Blurring of optic discs especially the right.

From this date onwards patient's condition became daily worse. No other characteristic signs appeared. On the 26th, lumbar puncture was performed and a small quantity of opalescent fluid removed. This relieved the patient temporarily. On the 5th of March he became comatose and he died at noon on the following day.

No post-mortem possible.



*May 13th* — Relapse with exacerbation of all symptoms especially headache Patient distinctly weaker The headache and cervical rigidity were marked for three

days, but on the 21st with an improvement in his general condition, these symptom began to abate

May 26th — Patient convalescent He expresses himself as well with an obvious feeling of relief Not a trace of his disease appears to have remained Recovery was perfect in this case.

No II. हायु सग्ह 20 "Chick" matting

Name	Fauy Singh										Age 20										Disease Local General Neurologic										Result										Death																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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April 26th — Partly conscious Vomiting persistent Tongue dry and brown Frontal headache troublesome Epistaxis

April 27th — As yesterday Headache severe Cervical pain and rigidity marked. Difficulty of articulation Strabismus left eye Constipation

April 29th — Strabismus right eye as well as left convergent

April 30th — Patient very weak herpes labialis has appeared.

May 2nd — (C J R M)

T 100 F Pulse 90 fairly full. Resp 30.

Patient semi conscious drowsy obviously very ill Frontal headache very severe Retraction of head Cervical rigidity and marked tenderness over cervical spine. No deafness No aural discharge No conjunctivitis Internal strabismus left eye only Lips dried up, herpetic eruption

Tongue coated, white, inclined to be dry on dorsum Breath foul

Circulatory system nothing abnormal. Pulse less compressible than in previous case

Respiratory system No coryza No pneumonic nor bronchitic signs

Digestive system Appetite poor Bowels inclined to be constipated No enlargement of liver or spleen. No abdominal tenderness

Urine Slight amount of albumen

Reflexes Superficial active Deep normal Kernig's sign present on both sides 5 P.M. Lumbar puncture 15 cc of purulent fluid removed

May 4 — Condition unchanged Convulsive twitching of fingers present.

May 6 — Condition shows distinct improvement On the 8th a painful relapse occurred. Headache and spinal pain persisted in an intense fashion Vomiting and delirium at night also returned Patient steadily became worse and when seen again

No. III Rasul Khan-18 "Chick matting"

[illegible]

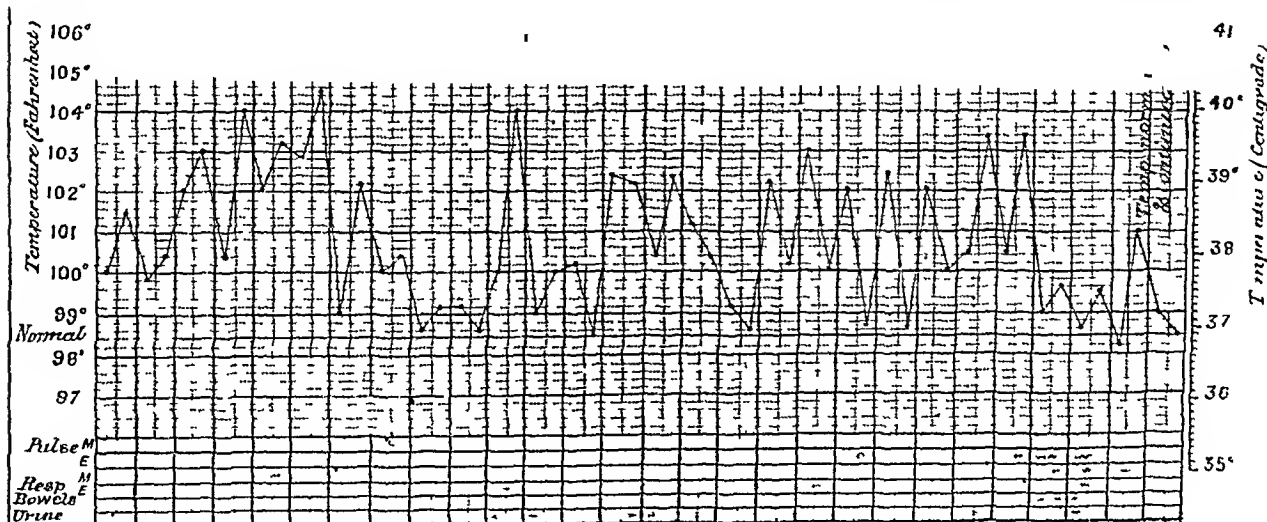
April 26—Admitted into hospital from barrack XII complaining of severe headache, fever, etc. Bowels constipated, conscious

April 27 - Violently delirious crying all night with pain Vomiting present Tongue dry Lips covered with sores

April 28.—Patient very ill: moribund  
Cervical rigidity marked, also epistaxis Died  
at 1-30 p.m.

*Post-mortem* Body well nourished. Rigor mortis marked Skull opened dura mater congested. Patches of purulent lymph in pia-arachnoid over both hemispheres Clear cerebro spinal fluid in excess poured from the spinal canal Lungs congested float in water Other organs healthy.

No IV Albar Khan, aged 22, employed at "chick matting"

[illegible]

April 27—Patient admitted into hospital from barrack XII Severe headache and vomiting Became unconscious towards evening and was noisily delirious all night

April 28—Partly conscious Headache very troublesome Cervical rigidity marked

May 1—Symptoms have continued Epistaxis present in less amount than in other cases

May 2—(C J R M) T 103.2° F Pulse 102 Resp 30

Patient looks ill, but is quite conscious and answers questions rationally Frontal headache Cervical rigidity and pain marked Slight convergent strabismus Decubitus posterior Knees kept in a position of semiflexion Pain referred to right knee, which is slightly swollen (Periarthritis). No deafness, aural discharge, nor coriza No circulatory nor pulmonic disturbance

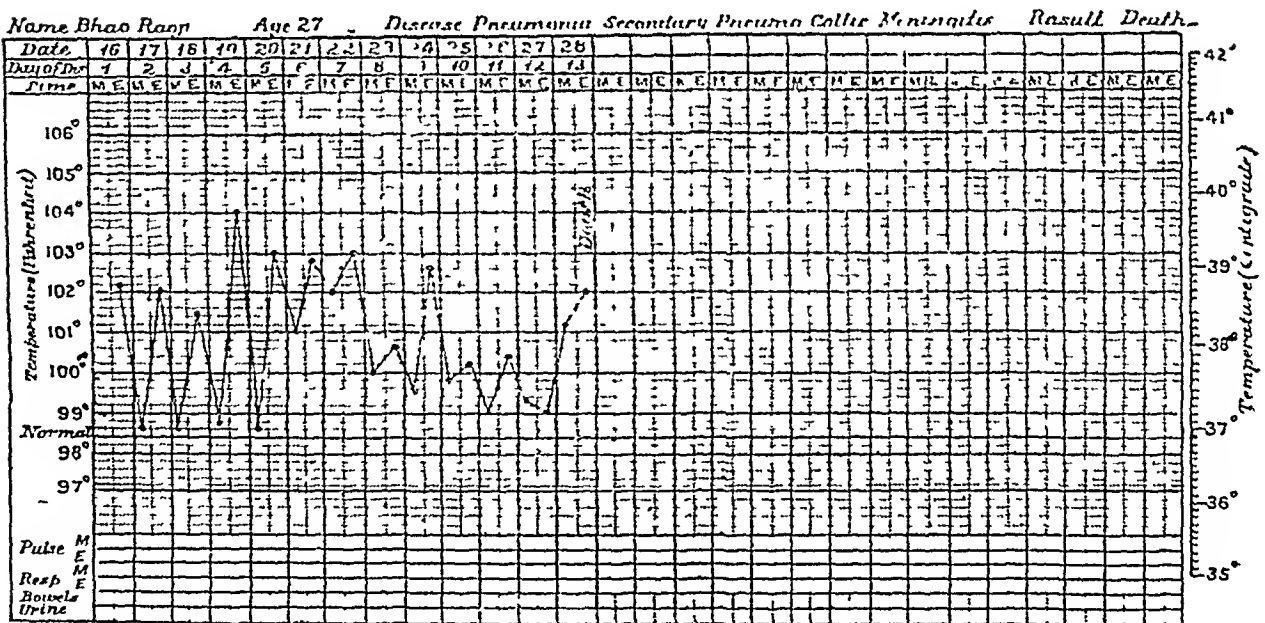
Appetite moderate Tongue coated Bowels loose and passed in bed from debility Urine normal Reflexes as in other cases Kernig's sign present on both sides, especially marked on the right.

May 3—Lumbar puncture. 15 c.c. of clear fluid removed In this case the symptoms persisted until the 21st Diarrhoea was a very troublesome complication Insomnia was also marked On the 21st a distinct improvement set in which continued On the 26th when I saw him for the second time he was distinctly better, but extremely weak A certain amount of cervical rigidity and Kernig's sign were still present Patient soon became quite convalescent and has recovered completely.

(b) Cases of Cerebro Spinal Meningitis due to the Pneumococcus

I Cases of Pneumonia with secondary meningitis Yarrowda Central Prison, Poona, April 1901 Notes received from Major J Jackson, Acting Inspector General of Jails

Bhao Raoji. 27. "Printing press"



Had an attack of ague on April 7th, again on 9th treated in hospital and discharged cured on 14th, but was re-admitted on 16th with the following condition Temp 102.2° F. Complained of pain radiating from the right nipple was very restless, lay generally in a flexed position, but was constantly moving his head or a limb about

Marked photophobia and myosis Reflexes normal Kernig's sign absent, On the 20th he developed a cough with copious expectoration, yellowish, sticky with a consistence like marmalade Physical signs not marked Slight dulness and faint tubular breathing all over right lung From 23rd condition become worse Increasing cerebral irritation, finally becoming delirious and then comatose, dying on the 8th April.

*Post-mortem* Brain and spinal cord Membranes congested, a thick deposit of greenish-yellow lymph over cerebral hemispheres and also at base of brain round medulla and on the posterior aspect of the cord 2 oz of fluid in each lateral ventricle and about 6 oz at the base of the brain and cerebellum.

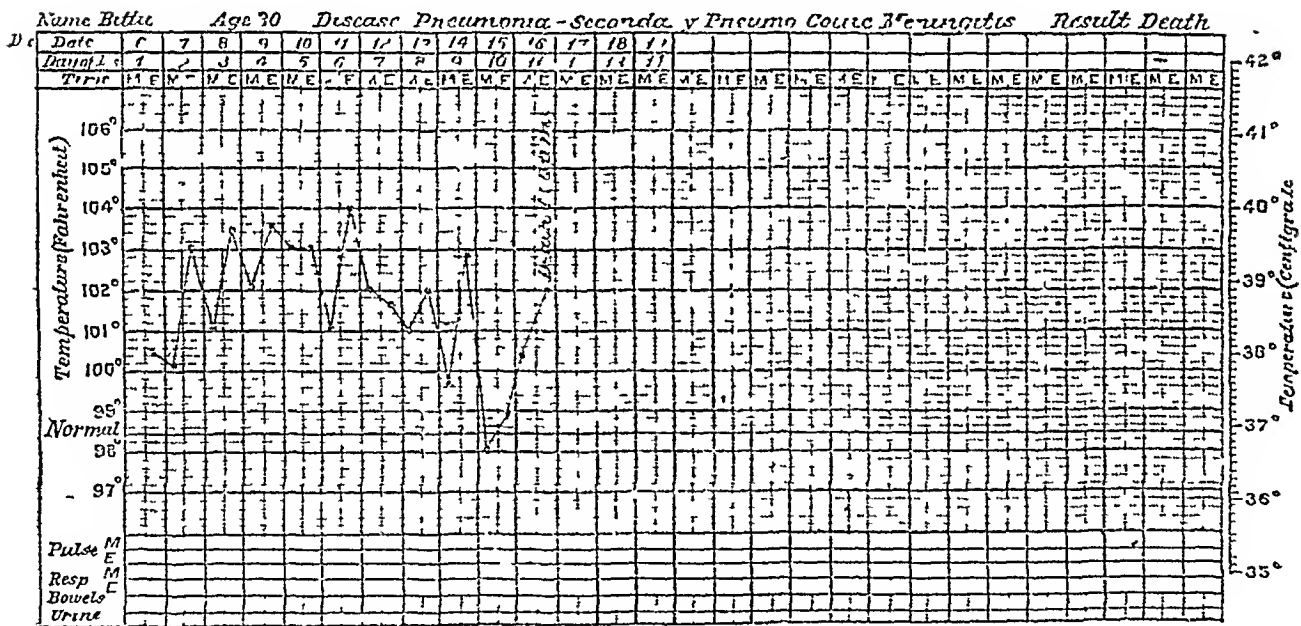
Lungs left slightly congested Right weighed 57 ounces Bright crimson-adherent everywhere, all lobes glued together, cut on section like liver and sticky yellow matter exuded from bronchioles

Other organs congested

Bacteriological note by Lamb. Lung alveoli filled with fibrin containing polynuclear cells (breaking down) and pneumococci Fibrinous exudate over brain and cord also contains polynuclear cells and pneumococci

2 Case of pneumonia with secondary meningitis from the Medical College Hospital, Calcutta (Wards of Dr Harris) (a) Notes supplied by Major Drury.

Bittu 30 H M Peon



Admitted on the 6th of December 1903 suffering from a choleraic attack. Temp. 100.6° F On the 7th the diarrhoea, which was yellow and foecal, continued. Urine was passed in the evening. Pyrexia had persisted and his temperature at 6 P.M. was 102° F No affection of the lungs could be then made out. The diarrhoea ceased, but the pyrexia continued On the evening of the 9th cough began to be troublesome. Examination of chest revealed left apical pneumonia On the 10th and 11th he was delirious at night On the 12th the delirium persisted throughout the day and the patient's condition was grave Patient continued to get worse. Hiccough was troublesome on the 14th, and on the following day, after being violently delirious for some hours, patient became unconscious He rallied slightly the next morning, but relapsed towards evening, dying shortly after midnight. Headache and the ordinary signs of meningitis were never present

*Post-mortem*—8½ hours after death. (F J D)

Heart Some pericarditis external and internal exudation not examined—valves and endocardium healthy muscular substance rather soft and pale

Left lung fibrinous exudation all over pleura (not examined microscopically), whole of upper lobe in a condition of red hepatitis

Right lung congested no consolidation.

Liver and spleen rather enlarged

Brain opaque subarachnoid fluid surface much injected, yellowish specks over meninges and a layer of fibrinous lymph all over, but more marked on right side, can be separated as a false membrane Opaque fluid also at base of brain and can be seen flowing from vertebral canal on removing brain *Diplococcus pneumoniae* found in great numbers in the fluid in smear preparations and was also cultivated on agar and serum Some opaque fluid also found in the lateral ventricles

Spinal cord marked injection of posterior surface Dorsal region there is a deposit of yellowish lymph posteriorly No lymph could be made out on the anterior surface, but the vessels were injected.